A DICTIONARY

OF

PHOTOGRAPHY,

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LONDON:

SAMPSON LOW, SON, & MARSTON,

MILTON HOUSE, 59, LUDGATE HILL.

1867.

LONDON:
WILLIAM STEVENS, PRINTER, 37, BELL YARD,
TEMPLE BAR.

PREFACE.

The first edition of the Dictionary of Photography, published in 1858, has been out of print for several years. In consequence of this, and the continued demand for the work, the publishers have entrusted the present editors with its entire supervision, in the belief that a new edition would be a desirable boon to photographers, by supplying them with a book of easy reference, in an alphabetical form, whereby they will be saved the trouble of wading through elaborate and often badly arranged treatises to find information on the subject to which they wish to refer.

It has been the desire of the editors to condense rather than to expand the matter contained in this volume, and to make it as thoroughly practical as possible. With this object in view, they have eliminated the debateable theories and speculative articles which occupied a prominent position, especially in the first part of the previous edition, and they have abridged other articles which, at the present time, are of less importance to photographers than they were in the year 1858.

In lieu thereof, a great deal of practical matter has added, including all the new *useful* processes; many

original articles have been re-written in a spirit more consistent with the present advanced state of the art; the preparation and properties of the necessary chemicals and the theory and construction of the different optical instruments required have been succinctly described; but a *detailed* account of the different kinds of cameras, printing frames, stands, and some other photographic items has not been given, because a complete description of what can be seen at any photographic warehouse would be entirely out of place in a work of this kind, and would have occupied too much space.

The aim of the editors has been to make this work a photographic *multum in parvo*. How far they have succeeded photographers themselves must determine.

The editors would take this opportunity of expressing their obligations to an American gentleman, who desires in the meantime to be anonymous, for some valuable hints and articles kindly volunteered by him for this edition of the Dictionary.

THOMAS SUTTON.
GEORGE DAWSON.

January 8th, 1867.

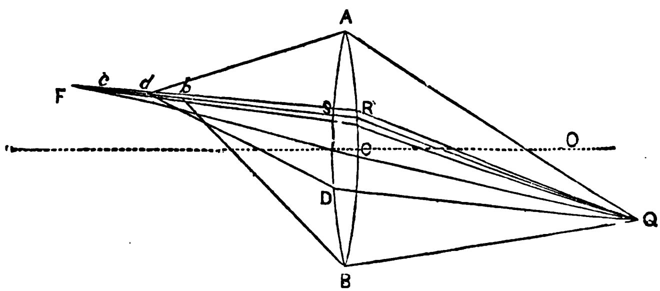
A

PHOTOGRAPHIC DICTIONARY.

Aberration. (Lat., *ab*, from, *errare*, to wander). This is a term much used in Optics. When a pencil of light suffers either refraction or reflection at the surface of any medium, it generally happens that the directions of the refracted or reflected rays do not all pass accurately through a point, or focus. This error is called "aberration," when the pencil is a direct one. The term, however, is not applied to those cases of confusion which occur in refraction through a lens, when both the incident and refracted pencils are oblique. It will be understood that we speak now of "spherical aberration;" that is to say, of the aberration which is produced entirely by the spherical form of the surface of the medium; the term spherical including the case of refraction at a plane surface, since a plane may be considered as a sphere of infinite radius.

Fig. 1 will serve to explain a common case of spherical aberration in a large pencil refracted through a lens, the incidence at the front surface being oblique, and the emergence at the posterior surface being direct.

Fig. 1.



Let A B be a single convex lens, and Q A B a pencil of l incident upon it, proceeding from a luminous point Q. The pe

after refraction through the lens, will not form a cone of light in which all the rays come to a common focus, but an effect will take place which it is important clearly to understand. In the first place, the emergent pencil is symmetrical with respect to an axis F S, which axis produced passes through the centre O of the posterior spherical surface A S B. The refracted rays which emerge from the immediate neighbourhood of the point S form a *small* pencil, which may be considered as having a focus F, called the "geometrical focus." The outer rays of the emergent pencil will cut the line S F at points *c*, *d*, *b*, as shown in the figure; the distances F *c*, F *d*, F *b*, increasing as the distance from S of the point of emergence of a ray increases. F *b* is therefore called the aberration of the ray Q B, F *d* of the ray Q D, F *c* of the ray Q C, and so on.

Moreover, these distances F *b*, F *c*, &c., are affected with the sign + (plus), in order to indicate that they are measured from the geometrical focus F *towards* the origin Q of the incident pencil. Had they fallen on the other side of F, they would have been affected with the sign − (minus). Aberration is therefore called "positive" or "negative," according as it is affected with the sign plus or minus.

When F S is large compared with S A, the aberration F *d* is proportional to the square of S A.

It is impossible to construct a single lens with spherical surfaces, so that the pencils shall be entirely free from aberration; but, by combining two or more lenses, made either of different kinds of glass, or of the same kind of glass, spherical aberration may be to a great extent, although not entirely, corrected. Such compound lenses, or combinations, are said to be "aplanatic."

There are certain forms of reflecting and refracting surfaces and lenses in which a particular pencil is reflected or refracted without aberration. The cases with which the photographer is chiefly concerned are those of the parabolic and spheroidal mirrors. All rays incident on the surface of a parabolic reflector, in directions parallel to its axis, are reflected in directions which pass through its focus; and all rays incident on the surface of a prolate spheroid, in directions which pass through one of its foci, are reflected in directions which pass through the other focus.

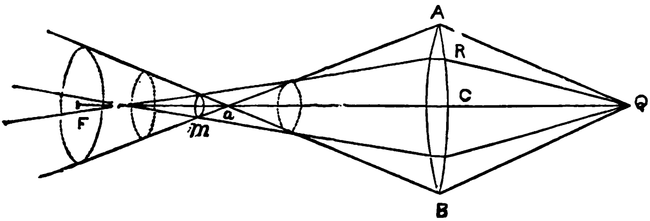
It is a common error to confound spherical aberration with curvature of the image. Curvature of the image may exist where there is no spherical aberration, and *vice versâ*. *See* "Curvature of the Image."

The nearest approach to a correct focus which can be obtained

with a lens, when a large aperture is employed, is called the "least circle of aberration."

It will be seen in Fig. 2 that, if the various rays of a refracted pencil are produced through the axis, there will be a certain position, *m*, of a circular area through which they all pass, in which the diameter of that circle will be the least possible. If F *a* be the aberration of the pencil, the distance of this least circle of aberration from F is three-fourths of F *a*; and if the aperture of the lens A B be small compared with its focal length, C F, then the diameter of the least circle of aberration is proportional to the cube of the diameter of the part of the lens employed.

Fig. 2.



When we speak of the focus of a direct pencil, we mean the least circle of aberration of that pencil. It is evident that the smaller the diaphragm of the lens, the smaller will be the diameter of this circle. In view-lenses, in which correction for spherical aberration would be inconsistent with other important conditions, a small diaphragm is the only means which can be employed for obtaining sharp definition.

Aberration, Chromatic. The light which proceeds from the sun, and most luminous bodies, is found to be heterogeneous; that is, composed of different kinds of light, of different degrees of refrangibility. If a ray of such light be refracted through a prism or lens, it will be decomposed into its constituent rays; and if a direct pencil passes through a lens, there will be formed a system of emergent pencils, corresponding to the different kinds of light of which the incident pencil is composed. Sunshine is found to be composed of light of seven different colours; viz., red, orange, yellow, green, blue, indigo, violet; arranged in the order of their refrangibility, red being the least and violet the most refrangible. When, therefore, a pencil of sunshine is refracted through a convex lens, the foci of the coloured pencils are arranged along the axis of the lens in the order of *refrangibility*. If we designate these foci by the

letters *r*, *o*, *y*, *g*, *b*, *i*, *v* (*r* being farthest from, and *v* nearest to the lens), the distance between *r* and *v* is called the "chromatic aberration" of the pencil.

It is found that by combining *n* lenses made of *n* different kinds of glass, according to a certain formula, *n* different coloured foci may be united in the same point upon the axis. When two or more foci are thus united, the lens, or combination of lenses, is said to be "achromatic," or corrected for chromatic aberration. If it were not for the property called "irrationality of dispersion," the same arrangement by which *two* of the coloured foci were combined would suffice to combine *all* the colours.

Accelerator. This name is often given to any substance which shortens the time of exposure, either in the camera or in the printing-frame. The term is, however, so indefinite in its application that it ought to be discontinued.

Accessories. By this term is commonly meant the various ornamental articles of furniture, vases, columns, balustrades, curtains, &c., which photographers employ in connection with portraiture. With respect to taste in the choice and arrangement of such objects, little can with propriety be said in a work of this kind. The portraitist will find it a highly advantageous plan to have all such objects coloured of some shade of grey—lighter or darker, as the case may be—and not of a variety of colours which have different actinic properties, and which therefore might mislead the eye in arranging the light and shade of the picture. Varnished surfaces should also, as a rule, be avoided, because they produce by reflections disagreeable spots of high light in the photograph. It is hardly necessary to remark, also, that solid accessories should always be preferred to flat pictures of objects in questionable perspective. Care should always be taken not to overload a picture with accessories; the aim should rather be to make them so entirely subservient to the principal figure as that the eye should not be inclined to dwell upon them too much, or the mind become too conscious of presence.

cetates. Compounds of acetic acid with bases. Some of the ates are used extensively in Photography for displacing free ic or sulphuric acids from solutions, in which such acids are jrious. They are also used in conjunction with chloride of gold the toning bath. They are formed by dissolving the oxides in or by adding acetic acid to the proper carbonates, when id is expelled with effervescence. The salts of acetic st, without exception, soluble in water. The general

formula for the acetates is $MO, C_4 H_3 O_3$. The acetates used in Photography will be described under their respective bases.

Acetic Acid. $C_4 H_3 O_3, HO$ or $Ac O_3 HO = 60$. Acetic acid is obtained either by the oxidation of alcohol or by the destructive distillation of wood.

When wine, beer, and other fermented liquors are exposed to the air under certain conditions, an oxidising action, sometimes erroneously called acetous fermentation, is set up, and the alcohol which they contain is gradually converted into acetic acid, or vinegar, by the removal, first, of two equivalents of hydrogen, whereby aldehyde is formed. The aldehyde then combines with two equivalents of oxygen, and is converted into acetic acid.

Another method of preparing acetic acid consists in subjecting, for several hours, any of the hard woods, such as beech, oak, &c., which must be quite dry, to a red heat, in an iron retort or closed cylinder, to which is attached a condenser. Charcoal remains in the retort, and in the condenser is found a liquid, consisting of acetic acid, tar, water, &c. This liquid is redistilled, and afterwards converted into an impure acetate of soda, which is purified from tarry matter by cautious fusion and recrystallization. It is then decomposed by strong sulphuric acid, diluted with about half its weight of water. The acetic acid thus formed is purified by distillation.

Other methods have been devised and are practised for obtaining acetic acid from wood, but the above process yields the purest acid.

Acetic acid, prepared by either of the above methods, contains a large proportion of water. By repeated distillation it becomes stronger; but the acetic acid commonly called "glacial," which crystallizes at 40° Fahr., is most conveniently obtained by distilling 82 parts of anhydrous acetate of soda with 49 parts of monohydrated sulphuric acid.

The strength of pure acetic acid is very variable, and cannot be determined by its specific gravity. The most constant is the "glacial," which below 40° of temperature becomes solid. When it does not solidify, the only means of knowing its strength is by observing the quantity of crystallized carbonate of soda which is necessary to neutralize it. The dilute acetic acid of the London Pharmacopœia, sold by the druggists, should be such that one fluid ounce saturates 57 grains: the acetic acid *fortior*, of the Pharmacopœia, or the acid called Beaufoy's, should take 390 grains to the fluid ounce; and the glacial requires 1036 to the ounce, or about 129 to the fluid drachm. When pure, any of these may be us

calculating from these numbers the equivalent measures. The numbers 1, 7, and 18 are near enough; but it would be better if a standard acid were used by photographers, easily verified by a standard solution of carbonate of soda.

The acetic acid of commerce is often contaminated with impurities, which are very injurious in some photographic processes in which it is employed. Nitrate of silver is a very convenient method of detecting those that are hurtful. Proceed in this way:—To a small portion of the suspected acid placed in a test-tube or wine-glass, add a few drops of solution of nitrate of silver. If a milkiness or precipitate of any kind is produced, the acid probably contains hydrochloric or sulphurous acid. If no precipitate is immediately formed, place the test-tube in a strong light for some time, when, if any organic impurity is present, the liquid will become discoloured.

In several of the photographic processes acetic acid is extensively used, and it is therefore important to be able to obtain it pure, and of a definite strength. By the above tests any injurious impurity can immediately be detected, and the strength can be estimated by the method already pointed out.

Achromatic. A lens, or combination of lenses, which is employed to give a real image of an object placed before it, is said to be achromatic when the image is seen free from any coloured fringe round its edges. Eye-pieces of microscopes and telescopes are said to be achromatic when all the heterogeneous rays of which an emergent pencil is composed are parallel, and therefore enter the eye in such a manner as to produce a focus of white light upon the retina. The conditions of achromatism are therefore different for object-glasses and eye-pieces. Huygens' eye-piece is achromatic; Ramsden's not. It is customary now to use the term "actinic" instead of achromatic, when speaking of photographic lenticular combinations, in which the visual and chemical rays are united, in preference to the yellow and the blue.

Acids. Acids have been defined by Gerhardt to be salts of hydrogen. According to this view, the most common way in which they react or form combinations with other substances is by double decomposition, whereby one equivalent of the metal takes the place of one of the hydrogen. This is, however, still a disputed scientific question, which need not be discussed here.

The properties common to most acids are—1. They have a sour taste. 2. They redden blue colours. 3. They are soluble in water. 4. They destroy the characteristic properties of alkalis. 5. They decompose most of the carbonates. But it must not be

supposed that all acids possess these properties, nor that there are not other substances to which they are equally applicable. Alum (sulphate of potash and alumina), for instance, which is not an acid, possesses them all.

Acids may, for convenience, be divided into two classes—1. Oxacids, or oxygen united to a metalloid, such as sulphuric acid (sulphur and oxygen). 2. Hydracids, or hydrogen united to a metalloid, as hydrochloric acid (chlorine and hydrogen).

When several acids are formed from the same elements, they are distinguished by their termination, or by a prefix. Thus, to take a familiar example, sulphur*ous* acid contains the smallest proportion of oxygen of the sulphur acids, and sulphur*ic* acid the highest; but when an acid, containing the same elements, but less oxygen, intervenes between the two, the prefix *hypo* is used, as *hypo*sulphurous acid. Or, again, if an acid is discovered containing more oxygen than the terminal *ic* would denote, the prefix *hyper*, or, more shortly, *per*, is adopted; as *per*manganic acid, which contains more oxygen than manganic acid.

It may be observed, that when the terminal syllable of the name of an acid is *ic*, the salts formed from it end in *ate*, as nitr*ate* of silver (nitric acid and silver). Salts formed from acids ending in *ous* have the terminal *ite*, as nitr*ite* of silver (nitrous acid and silver). Also the distinguishing prefix, when there is any, must be used; as *hypo*sulphite of soda (hyposulphurous acid and soda). These rules hold good in every case without exception.

The different acids employed in Photography will be treated of in this Dictionary under their respective headings.

Actinic. A compound lens is said to be "actinic" when the real image which it gives upon a screen is such that a large number of those coloured rays which exert a chemical action upon the substances composing the sensitive photographic tablet are combined with sufficient of the luminous rays to render the image visible. According to this definition, an achromatic lens is not necessarily actinic. Some lenses, which give an image devoid of colour, have not their chemical and visual foci coincident.

Actinism. (Greek, *ακτιν*, a ray). A ray of light, whether proceeding from a heavenly or terrestrial body, is found, in general, to possess three properties; viz., the luminous, the calorific, and the actinic. The actinic is that property of the ray which produces important chemical changes in certain substances submitted to its action, and on the use of which the whole art of Photography is founded. When a ray of light is decomposed by refraction thr

a prism into its constituent colours, it is found that actinism exists chiefly among the violet, and scarcely at all among the yellow and red rays. Hence the importance of combining the violet or actinic focus of a photographic lens with the yellow or luminous focus: for the actinic rays produce the photographic picture, while the luminous rays render the image visible upon the focussing screen.

It must be remembered, when speaking of actinism, that both light and heat produce chemical changes in some bodies. It is not, therefore, sufficiently exact to say that actinism is the chemical property of rays.

Actinograph. An instrument for measuring the chemical action of the sun's rays. Hunt and others have described several forms of this instrument, all of them depending on the same principle; viz., the depth of the blackening effect of the chemical rays allowed to fall on a sensitive sheet of paper during a given time.

Affinity, Chemical. That power of attraction by which dissimilar substances combine with each other to form compounds. Bodies invariably combine with each other in definite proportions, and the compound formed possesses properties different from either of its elements.

Agate Burnisher. Positive prints on plain paper are sometimes "mealy" and deficient in vigour. In such cases it is thought by some persons an improvement to impart a smoothness and glaze to the surface of the paper by rubbing it all over with a polished piece of agate. In this operation the paper should be laid face upwards on a slab of plate-glass, marble, or other hard polished substance.

Alabastrine Positives. This is a term applied to collodion positives, in which the film, after being coloured with dry pigments, is rendered permeable to varnish, and thus shows the colour in the collodion itself. There have been many methods described by which this can be effected, and some of the results are very beautiful, but the process is now little practised, chiefly, perhaps, because it entails a great deal of trouble.

Album. This word means, in its literal sense, anything white; term is now generally applied to books with handsome bindings, which photographs, &c., are preserved in a fit state to be examined hout fingering or injuring the articles exhibited.

Albumen. This compound is found dissolved in flesh and in imal fluids, but in Photography it is derived from the white of an 1 is its purest natural form. In this state it is soluble in heat of from 140° to 160° coagulates it or changes it into

an isomeric compound, no longer soluble in water. Albumen is also coagulated or precipitated by strong acids, by many of the metallic salts, and by several organic reagents.

When carefully dried at a temperature under 140° Fahr., it shrinks up into an amber-coloured gummy mass, which cannot now be coagulated by heat, although it is still soluble in water, thus showing that the presence of water is necessary for its coagulation.

A characteristic of albumen, which is of importance in Photography, is its property of forming with nitrate of silver a definite compound, from which the whole of the silver cannot afterwards be removed by the usual fixing agents. *See* "Silver, Albuminate of."

When albumen has been kept for some time in aqueous solution, it decomposes and, among other products, yields sulphuretted hydrogen, easily recognized by the smell. In this state it is quite unfitted for all photographic purposes, and should never be used. Two or three drops of strong ammonia added to half a pint of albumen solution tends to preserve it from putrefaction for a longer time. A little acetic acid is said to have the same effect.

The chemical composition of albumen is not positively known. Its properties vary slightly with the source from which it has been obtained, the differences sometimes consisting in the mineral constituents, and sometimes indicating various modifications of the same substance.

Albumen-Negative Process on Glass. *To prepare the Albumen.*—Collect in a basin the whites of a number of eggs, carefully separating the germ and all portions of yelk. To each ounce of this albumen add one drachm of distilled water, in which is dissolved 6 grains of iodide of potassium; also to every 5 ounces of the mixture add one drop of ammonia. Beat the whole to a stiff froth with a bunch of quills, and allow the liquid to settle till the following day.

To albumenize the Plate.—The glass plate must first be cleaned very thoroughly, and polished with a cambric handkerchief just before use. Attach to the under-side of it a gutta-percha plate-holder, having a wooden handle a foot long. Then breathe on the plate, and, holding it horizontally in the left hand, pour upon the centre of it a sufficient quantity of the albumen from the basin to cover it, allowing the albumen to filter through an opening in the dry froth or crust. Make the albumen flow backwards and forwards over the plate three or four times, and then let it all run off into a separate basin, from which it must be carefully filtered before being used a second time. In coating the plate, be particularly carefi

to prevent air-bubbles from forming upon it. Next, take the handle of the plate-holder between your hands, and, with the plate in a vertical position, spin it round quickly for a minute or so, in order to drive the albumen to the edges by centrifugal force. This done, remove the excess of albumen from the edges by means of a pipette (*see* "Pipette"), and dry the plate before a clear fire, keeping it rotating all the time by means of the handle, as before directed. When dry it is ready for the next operation. Albumenized plates may be put away in a plate-box, and kept for a considerable time without deterioration in a dry place. Care must be taken, in the operation of albumenizing the plate, that no particles of dust adhere to it.

To excite the Plate.—Place it on a dipper, and immerse it quickly and without hesitation in a vertical bath of aceto-nitrate of silver, made thus: Distilled water, 1 ounce; nitrate of silver, 50 grains; glacial acetic acid, 1 drachm. Leave it in the bath for a couple of minutes, then wash it well in clean water, and lastly in distilled water, and set it up to dry. When dry put it away in the plate-box until ready for use in the camera. It may be preserved in a sensitive state for several days. Some persons add a few drops of a solution of iodide of potassium to a new nitrate bath, and filter it on the following day, in order to saturate it with iodide of silver. When this is done a new bath is not so liable to attack the iodide of silver in the film.

The Exposure.—Albumenized plates, from which the excess of free nitrate of silver has been removed by washing, are, whether used in a dry or wet state, extremely insensitive to light; but, when only slightly washed, exposed at once, and developed with a strong developer, a much shorter exposure is sufficient. This should be timed solely with reference to the shadows, the lights being left to take care of themselves. When the camera is properly constructed, so as to prevent stray light from falling on the plate, it is hardly possible to over-expose a dry, washed, albumenized plate.

To develope the Image.—First immerse the plate in distilled water; then place it on a levelling-stand, and pour over it a saturated solution of gallic acid, to which a few drops of aceto-nitrate of silver have been added. The development occupies about twenty minutes.

To fix the Picture.—Wash the plate in rain water, and pour over it a nearly saturated solution of hyposulphite of soda. This will quickly remove the yellow iodide of silver from the film. Then wash the plate well under a tap, and dry it before the fire.

The negative may be varnished with any good varnish (*see* "*Varnish*"), but this is not always done.

Albumen—Dia-positive Process on Glass. Positives obtained by this process are intended to be viewed by transmitted light. The manipulation is so nearly identical with that of the albumen-negative process, described in the foregoing article, that it is only necessary to point out the difference between them.

The negative to be copied is placed either in a copying camera (*see* "Copying Camera"), or in direct contact with the sensitive plate in a pressure-frame. In the latter case the plate must be used dry, and the exposure to diffused daylight, or artificial light, only occupies a few seconds; in the former case, the plate may be either dry or wet, and the exposure is considerably longer. The wet process is the least troublesome, and yields the best results, because the operations of exciting, exposing, and developing may then succeed each other at once, and less time is allowed for a combination to take place between the silver and albumen, which causes the lights of the picture to assume a yellow tint. The development is also a much quicker operation in the wet process, more nitrate of silver being allowed to remain on the plate, and for this reason also the lights are less likely to assume a yellow tint.

The difference between this and the negative process consists chiefly in the employment of a gold toning-bath, in order to vary and improve the tint of the finished picture. This may be done in the ordinary gold-toning bath (*see* "Toning Bath"), and the picture afterwards fixed with hyposulphite of soda.

Dia-positives on glass should be viewed with the plain side of the glass next the eye; and against the film the rough side of a finely-ground glass should be placed, the two glasses being bound together at the edges with a strip of tape or paper pasted over them. In this way the print is protected from injury, and has a proper semi-transparent background.

The chief use of this process is for printing transparent slides for the stereoscope. In this operation it must be remembered that the picture taken from the right station must be viewed by the right eye, and *vice versâ;* and also that the objects in the view must not be reversed as regards right and left. It may therefore be necessary to place the negative in the copying frame with its back to the lens. Matters of this kind must be carefully considered by the operator; and his ingenuity will suggest the proper way of proceeding in every case. No general rules need be laid down in this place.

Albumenized Paper. Paper which has been covered with a coating of salted albumen. This paper is used in the positive printing processes *in combination* with nitrate of silver. The object of

the albumen is to give to the surface of the paper a finer finish, and to ensure a greater variety and brilliancy of tints in the prints obtained. It also gives the power of rendering the details of the negative with extreme sharpness and great transparency in the shadows. But, on the other hand, the glazed surface is considered by some objectionable, as being vulgar, and inartistic.

To prepare the Albumen.—Take a sufficient number of fresh-laid fowls' eggs, which, on an average, contain one ounce of albumen each. Break each egg on the edge of a cup, and collect the white, carefully rejecting the germ and yelk. Put all these whites together into a large basin, and for each egg add from 5 to 15 grs. of common salt, the weight being regulated by the following considerations:—

If the subsequent exciting solution of nitrate of silver be a weak one (not exceeding 50 grs. to the ounce), the proportion of salt should be low; but if it be strong (90 grs. of silver), from 10 to 15 grs. of salt may safely be used. The higher salted albumen, with a strong exciting bath, is the most sensitive to light, and prints with the deepest tone.

Should it be required to give less glaze to the paper, add to the albumen 1 ounce of water for each egg, and rather more than a corresponding quantity of salt, because less of the solution will now adhere to the paper.

When the materials are mixed in the proportions which may be thought best for the object required, beat up the whole into a stiff froth with a bunch of quills. This cannot be done too perfectly; for the more completely the membraneous cells containing the albumen are destroyed, the less liability is there to streaks on the paper. The addition of a few drops of ammonia to the albumen before it is whipped up assists to break the cells, confers greater limpidity, and is generally supposed to preserve the solution from putrefaction for a longer time. It is also not injurious to the paper, because it evaporates while the paper is drying.

Let the frothed albumen be transferred to a tall jar (covered over to prevent the ingress of dust), and allowed to repose for at least twenty-four hours. By that time the greater part of the vesicles will have condensed, and the membraneous shreds subsided to the bottom. Then decant gently into a flat-bottomed and shallow dish, the upper portions of clear liquid, avoiding, if possible, the passing over of particles of froth which may be still swimming on the surface, and also the membranes and other impurities which have settled. A good way of avoiding these is to filter the solution through two *folds of muslin*, taking care at the same time that the nozzle of the

funnel is very close to the bottom of the flat dish, otherwise another crop of vesicles of froth will be formed on the surface of the filtered liquid, which will have to be removed before a sheet of paper can be albumenized smoothly and regularly.

To albumenize the Paper.—The paper, having been selected according to taste, or the requirements of the process to which it is to be applied, is marked on the right side; *i.e.*, the smooth or upper side of the sheet, which does not show the wire-cloth markings. It is sometimes difficult to detect these wire-marks at a glance, when the paper has been rolled under great pressure, as it usually is; but it is important that the opposite or smoothest side of the paper should be covered with the albumen, otherwise the marks will be painfully conspicuous in the finished prints. A practised eye can detect them instantly, by holding up the sheet to a strong light, and looking on its surface at an acute angle with the incidence of the light. The safest way of detecting them is to float a small portion of the paper in water for two or three minutes, when the effects of the rolling disappears, and the small right-angled net-work made on the paper by the wires is easily discernible at a glance by any one. At the paper-mills the sheets are all laid in one direction, so that when the right side of one sheet is ascertained, the proper face of all the rest in the ream lies in the same direction; but in purchasing a quire from a retail house, it may happen that it is made up of odds and ends placed anyhow, in which case each sheet must be examined before being albumenized.

The albumenizing should be conducted in a warm and dry room. If not, the albumen sinks into the paper by absorption, before it has had time to dry, and the surface of the paper is left as dead as it was originally. This is the first precaution to adopt.

Secondly, arrangements must be made to continue the operation of albumenizing without intermission; otherwise stringy fibres, the effects of evaporation, are found on the surface of the liquid, and the next sheet laid down is either covered with air-bubbles, or the superfluous albumen drains away in streaky channels.

Thirdly, the room should be as free as possible from particles of floating dust, but they should not be laid in the usual way, by watering the floor, because that creates a damp atmosphere, which retards the drying.

Lastly, the paper should be perfectly dry.

When the above precautions are attended to, and the plain paper piled in order, with the smooth face downwards, and the narrow end towards the operator, all is ready for work. Pick up the sheet by the upper right and the diagonal left lower corners, with the

respective hands. Lay down the lower right-hand corner of the paper on the surface of the solution, close to the edge of the dish nearest the person; allow that end of the sheet to drop gently towards the left, taking care that no other part of the paper shall touch the albumen; then, the instant that the left hand is disengaged, it should seize the upper left corner of the sheet, and roll it over with slow and gentle pressure.

One minute, as a general rule, is quite sufficient for the paper to lie in contact with the albumen. Strongly-sized papers may remain longer with advantage, but those of an absorbent nature should be removed very quickly, to prevent the albumen from penetrating too deeply into its texture, the effect of which is always flat mealy pictures. Whilst the paper is lying on the albumen solution, the operator should watch for air-bubbles. They are easily discernible by a wrinkling-up of the paper at the part where they occur. In such cases have a camel's-hair brush near at hand, dip it in the albumen, and, after gently raising the paper by the corner nearest to the bubble, moisten the dry part with the brush, and lay down the paper again, when no bad consequences will ensue. The next sheet laid down will probably have an air-bubble at the same spot, from the dried external fibrous outline of the last, unless special care be used. The best way to avoid their recurrence is to rake over, to the edge of the dish, with the brush, the superficial deposit formed at that point before laying down another sheet.

In removing the paper from the albumen, it should be seized by the opposite corners at one end, and raised very slowly and steadily, avoiding jerks; the object being to take up as little surplus albumen as possible, which, if in excess, will run into lines instead of drying into an even surface. Allow to drain for about a minute, over the dish, keeping the sheet fully extended; then hang it up in the same position by two clips at opposite corners, or over a thick roller, to dry. The drippings may be collected in a convenient vessel, and used again, when slightly diluted.

The first few sheets floated on an albumen solution are seldom ~~rfect, no matter what precautions are adopted. There are always s surface-bubbles, and floating stringy fibres, which cannot be led; but they adhere to the paper and are soon removed. The us matter forms again on the surface, after a time, unless the menizing of the paper is continuous, and some sheets may be ed before they are entirely removed. The best way to get rid them, when a cessation of work is necessary, is to float on the t of rough blotting-paper before using the other.

of drying, thin paper is apt to curl up before the

excess of albumen has reached the draining corners. The solution in consequence may flow back and form streaks. This only occurs when the room is very warm; but it may be avoided by suspending two clips from the lower corners, or by a plan which the professionals sometimes adopt of moving the papers from place to place.

Albumenized paper should not be stowed away, nor piled together, until thoroughly dry. Professional albumenizers almost invariably roll their paper under great pressure before sorting it into quires. This is not only unnecessary, but it is deceptive, because it gives a fictitious glaze which disappears as soon as the paper is laid down on the sensitizing solution; it may also be injurious by impregnating the paper with particles of iron or copper from the rolling machinery.

Albumenized paper will keep without deterioration for many months, if stored in a dry place, but moisture or damp air soon destroys it. *See* also the article "Paper."

Albumenized Paper—Sutton's Patent. This paper is prepared with a solution of india-rubber in benzole, before being albumenized, in order that the albumen may not sink so deeply into it, and that the resulting picture may be as much as possible upon the surface of the paper, and therefore more brilliant, as well as probably more permanent. It is supposed by the inventor of the process that the benzole also removes from the paper some deleterious colouring matter, and renders it whiter. Necessarily this extra expenditure of time and materials adds to the expense of the paper, although it undoubtedly improves its quality.

Albumenized Paper, Printing on. *See* "Printing."

Alcohol. Formula, $C_4 H_6 O_2 = 46$. This organic compound is a hydrate or hydrated oxide of ethyle, and is formed when ether and water meet in the nascent state. Practically, however, it is obtained from solutions of sugar, malt, or other saccharine juice, by fermentation. The fermented liquor contains alcohol diluted with other substances, from which the alcohol, being more volatile, can be separated by distillation. After the first distillation, it will still contain from 30 to 40 per cent. of water, besides a volatile oil. By a second distillation it is still more highly rectified, and the product is called spirits of wine. A third distillation brings down the specific gravity to ·825 from ·836, and the product goes under the name of rectified spirits of wine. It still contains from 10 to 20 per cent. of water.

But it is impossible, by mere distillation, to reduce alcohol to a much lower specific gravity or to a more absolute state without having recourse to other methods of dehydrating it. This is do'

by mixing with the re-distilled liquid some substances which have a powerful affinity for water. The one most usually employed is quick-lime, which is reduced to a fine powder, and mixed with the spirits of wine in a retort. The neck of the retort is closed, and the whole allowed to digest for several hours, with occasional shaking up. The highly-rectified alcohol is then distilled over by means of a water bath, at a lower temperature than boiling water, care being taken that the distillation is not carried too far, otherwise the alcohol would be contaminated with lime.

Absolutely dehydrated alcohol has probably never been prepared, and therefore its specific gravity has been differently given by various investigators. The specific gravity of that kind which should be used in the preparation of collodion may vary from ·805 to ·820. The less rectified varieties are apt to make the collodion glutinous and difficult of manipulation. An inferior quality may be used in other photographic preparations, such as for dissolving caoutchouc and gutta-percha, for making plate-cleaning solutions, for adding to the developer to make it flow well, and for many other purposes where its strength and freedom from impurities are of minor importance.

The highly-rectified alcohol for collodion should not contain essential oils, because they quickly contaminate the nitrate of silver bath with organic matter. Fusel oil is the one most likely to be met with; but it is easy to avoid its passing over in the final rectification by distilling at a low temperature—fusel oil being less volatile than alcohol.

The tests for an alcohol fit for making good photographic collodion are:—1st. It should not redden litmus paper, nor restore the blue colour to litmus paper already reddened. 2. It should give no precipitate with nitrate of silver. 3. When mixed with a few drops of solution of nitrate of silver, and subjected for some hours to sunshine, there should be no discoloration. 4. The specific gravity should not exceed ·820.

Alcohol, Methylated. The high excise duties levied on the manufacture of alcohol from sugar, malt, &c., for potable purposes, interfered much with its extensive use in the industrial arts. It was therefore decreed by the Government that 90 parts of spirits of ‑ine might be mixed with 10 parts of purified wood spirit, and sold, e of duty, under the name of "Methylated Spirit," for manufac- ing purposes. The addition of the "wood spirit," it was then pposed, rendered the mixture so unpalatable and nauseous that it l not be drunk nor employed for any other object than dissolv- ns, making varnishes, &c.

The ordinary rectified methylated alcohol, which is very cheap, will answer well for all photographic purposes, save one—the manufacture of collodion. But, by some recent contrivances of filtering it through, or re-distilling it over, charcoal, not only may the spirit be rendered potable, but quite as well suited for making collodion as the purest alcohol. The process to which it is subjected deprives the methylated spirit both of its disagreeable smell and of its nauseous taste, and also fits it for the manufacture of a collodion quite as good as from pure spirit, while the price is only about one-third of the latter.

The great objection to the use of the unpurified methylated spirit in collodion is that it always contains fusel or other essential oils, which, combining with the silver in the nitrate bath, and being, partly soluble therein, soon contaminate it with organic impurities, which cause fogging in the negatives.

Alkaline Development. A term applied to the development of collodionized sensitive plates under certain conditions. The development is effected by an alkali, or an alkaline salt, combined with pyrogallic acid. It is necessary, however, in order to ensure success, that all salts of silver soluble in water should be absent, otherwise a general fogging of the image ensues. *See* "Tannin Process" and "Developer, Alkaline."

Alkalis. Without being too precise, an alkali may be defined to be a substance which destroys the characteristic properties of acids; but, strictly speaking, the term can be applied to only four substances—viz., potash, soda, lithia, and ammonia.

Photographically and generally speaking, any substance which changes vegetable blues to reds is an alkali. The protoxides of the metals, as a rule, possess this property, and specially do the so-called alkaline earths, baryta, strontia, and lime.

In Photography, the actinic effects of alkalis are opposed to those of the acids. Alkalis have a quickening influence, and acids the opposite; but it is only by a careful balancing of the two to a certain standard, ascertained by experiment, that the best effects can be obtained. In a nitrate of silver bath used in the developing processes, free alkali is objectionable, because, when combined with the developer, its predisposing action is to precipitate silver evenly over the whole plate or paper, instead of on those parts which have been actinically affected.

In the nitrate bath for sensitizing positive chlorized paper, which has not to undergo development, alkalinity is sometimes an advantage. Moderate alkalinity is also useful in the toning

processes with chloride of gold, and in the hyposulphite fixing-bath.

The most delicate test for alkalinity of any solution is moist litmus paper, previously reddened with the fumes of acetic acid, washed in distilled water, then, while still moist, immersed in the solution to be tested. The paper will turn blue instantly if much alkali be present, but more slowly according to the lessened quantity that may be in the solution.

Almond Oil. This is a drying oil, as colourless as water, and very useful for rendering paper, or paper negatives, semi-transparent. The paper should be left to steep in it for several hours; then be wiped and hung up to dry. If the oil should be found too thick for the purpose required, it may be thinned by the addition of benzole.

Allotropic. (ἄλλος, another, τροπος, form). When the same substance exists in two or more forms, having different properties, but still chemically the same, as albumen in the liquid and coagulated state, the unusual form is said to be allotropic. Light produces allotropic forms in some bodies, and certain temperatures do the same with others. Those who suppose the action of light to consist in a molecular disturbance of the sensitive surface, imagine it to produce by actinism these allotropic conditions of bodies.

Amber. A fossil resin found on some sea-coasts, and also in seams of coal; it is used in making amber varnish. *See* "Varnish."

Ambrotype. Collodion positives are sometimes called "Ambrotypes," in America.

Ammonia. $N H_3 = 17$. This substance is a compound of the hypothetical metal ammonium. Its elements are according to the chemical formula given above; but whether the metal ammonium exists or not has never been shown.

Ammonia is really a colourless gas, feebly combustible, and of a pungent smell; but it may be compressed by cold or pressure. Water also dissolves about seven hundred times its bulk of this gaseous substance, and forms a solution which goes under the name of *liquor ammoniæ fortissimus*, or, when more largely diluted, of *liquor ammoniæ*. But the real strength of the liquid does not depend on these arbitrary distinctions. It can only be estimated from the specific gravity, which diminishes with concentration, or more safely, by ascertaining how much acid of a known strength a given ntity of the ammoniacal liquid will neutralize. The latter is the d which is usually employed.

Ammonia is a powerful alkali, and is employed in several photographic processes for neutralizing acidity in solutions, for removing greasy matter from glass plates, and for many other purposes. Its strength is not a matter of much importance, but its freedom from impurities is, in some cases, to be attended to and avoided. An aqueous solution of ammonia may contain carbonate of ammonia chlorine, lime, copper or lead, and empyreumatic oil. None of these can do any harm in photographic solutions, except in those of nitrate of silver. And nitrate of silver may be made the means of detecting any one of them, by adding a single drop of a twenty-grain solution to a drachm of the suspected liquor. If, after the whole has been shaken up and subjected to a strong light for an hour, no precipitate or blackening effect takes place, the ammoniacal liquor may be used for the most delicate photographic purposes.

Tolerably pure ammonia can be so readily obtained at any retail shop that there is no necessity for describing here its mode of preparation.

Ammonia-fuming Process. It has been asserted that albumenized and plain salted paper, excited by an ordinary solution of nitrate of silver, is rendered much more sensitive to the action of light after being subjected to the fumes of ammonia. The process has been much practised in America, but in England the advantages claimed for it have not been appreciated, probably for good reasons.

The paper, after having been sensitized in the usual way and dried, is placed in a *fumigating* box, exposed to the vapour of liquid ammonia for some minutes. The ammonia converts part of the free nitrate of silver on the surface of the paper into oxide of silver, which is supposed to be the accelerating agent. For the sake of experiment, any wooden box will answer, by pinning down a sheet of sensitized paper (sensitive surface downwards, on the under side of the lid), sprinkling the bottom of the box with strong ammonia, and then shutting down the lid for five minutes. The sheet of paper is afterwards hung up in the dark room to allow the free ammonia to escape. The advantages of this process are very doubtful.

Ammonia, Carbonate of. There are several carbonates of ammonia. The one used in Photography for alkaline development, and sometimes for neutralizing acid solutions, is the sesquicarbonate $2\,N\,H_4\,O, 3\,C\,O_2$, but when exposed to the air a white bicarbonate is formed.

Ammonia, Hydrosulphate of. $NH_4\,S, HS = 51.$ Thi^r^

substance is obtained by passing sulphuretted hydrogen gas through a solution of ammonia. It is used in Photography for precipitating silver from its solutions, and for intensifying negatives. It should be kept in a well-stoppered bottle away from the operating room, because even in minute quantity the fumes from it have a powerful effect in causing fogging of the image.

Ammonia, Nitrate of. $NH_4\,O,\ NO_5 = 80$. This substance is formed in the nitrate bath when the iodide or bromide of ammonium has been added to the collodion, or when chloride of ammonium has been used for salting positive paper.

Ammonium. A metal which by analogy is supposed to exist, but it has not yet been isolated.

Ammonium, Bromide of. $NH_4\,Br = 98$. This salt is now largely used in the manufacture of collodion. It is more soluble in alcohol than the corresponding salt of potassium, and although not so much so as the cadmium salt, yet it has no tendency to render the collodion glutinous. It is also very stable. It can readily be prepared in a pure form by precipitating bromide of calcium with carbonate of ammonia.

Ammonium, Chloride of. $NH_4\,Cl = 53{\cdot}5$. Is much used in salting paper for positive printing, for which it is excellently adapted. It is prepared from the ammoniacal liquid of the gas-works, by a process which yields the salt in a very pure form.

Ammonium, Iodide of. $NH_4\,I = 145$. Is a salt very valuable in negative and positive collodion, because it has the property of giving limpidity, sensitiveness, and adherency to that compound, which, with other iodides, it often does not possess. It is, however, an unstable substance, prone to liberate iodine, and to decompose the collodion with which it is mixed, unless its bad effects are neutralised by other iodides, such as that of cadmium, which has an opposite tendency.

Iodide of ammonium is usually prepared by adding iodine to a strong solution of hydrosulphate of ammonia, until it begins to be coloured with iodine. On first adding the iodine a dense deposit of sulphur occurs. The solution is now acid. Neutralize with ammonia, filter, and crystallize. Dry *in vacuo* over sulphuric acid, and ep in hermetically-sealed bottles, away from light, if it be required preserve it for a long time from decomposition.

The iodide of ammonium of commerce is often contaminated with v impurities. Sulphate and carbonate of ammonia are the most nt. To detect either, a few drops of a concentrated solution

of chloride of barium will give a white precipitate if one or the other is present. A few drops of strong acetic acid added will distinguish between the two impurities. The precipitate is quickly redissolved after this addition, if it is caused by the carbonate. Not so, if caused by the other impurity.

Sulphate of ammonia, unless in quantity sufficient to materially weaken the strength of the iodide, does no other injury to the collodion. It is different with the carbonate. When that impurity is present in any iodide dissolved in collodion, it renders the nitrate of silver bath too neutral for good work, by a decomposition which it would be superfluous here to explain.

Ammonium, Sulphocyanide of. NH_4, S_2 Cy = 76. Has been proposed as a substitute for hyposulphite of soda in fixing positive prints. In a concentrated form it acts energetically, and may be considered a safer fixing agent than the hyposulphites, but its greater expense will probably prevent its being extensively used for this purpose.

Amorphous. This term is applied to those substances which do not crystallize in a definite form.

Amphitype. (Greek, *αμφὶ*, on both sides). A process discovered some years ago by Sir John Herschel, in which light produces either a positive or negative. A sheet of paper is first prepared with a solution, either of ferro-tartrate or ferro-citrate of protoxide, or peroxide of mercury, and then with a solution of ammonio-tartrate or ammonio-citrate of iron, the latter solution being in excess. On exposure to light in the camera, a negative is produced of more or less vigour, and of a very rich brown tint, when the paper contains a salt of lead. It gradually fades in the dark, but may be restored as a black positive, by immersing it in a solution of nitrate of mercury, and ironing it with a very hot iron.

Angular Aperture. The angular aperture of a lens is the angle which its diameter subtends at its principal focus.

Anhydrous. Many substances in chemistry have such a strong affinity for one or more atoms of water, that they seem incapable of existing without these atoms, or a base of some kind as a substitute. When the water is replaced by a base, or is otherwise entirely removed, the substance is anhydrous (*α*, not, and *ὕδωρ*, water). Glacial acetic acid contains one atom of water, which, when it combines with oxides or other bases, it liberates.

Aniline. C_{12} H_7 N. This very powerful base, which should more properly be called *Phenylamine*, is derived from indigo.

nitro-benzole, coal-tar, from the destructive distillation of animal matter, and from other sources.

When pure, aniline is a thin, colourless, highly-refracting oil, of a burning taste and aromatic flavour. Its specific gravity is 1·020. With acids it forms a remarkable variety of salts which crystallize with great beauty and facility. In combining with oxygen acids it acts very analogously to ammonia, by taking up one equivalent of water: like ammonia, it also combines directly with hydracids. In almost all other respects they behave similarly, so that the two may be considered analogous bases.

Aniline is remarkable for the beautiful colours which may be formed from it, most of which have been patented. With chromic acid it gives a deep green or bluish black colour, which has been taken advantage of in one of the photographic printing processes.

Aniline Process. Starting from the well-ascertained fact that aniline with chromic acid strikes a deep blue colour, Mr. Willis, after long and patient experiment, has lately discovered a photographic process which is designated by the above name. The process is still in its infancy, but it is already very extensively employed in the copying of engineers' plans and pencil drawings, for which it is eminently adapted.

Take any sample of good photographic writing or drawing paper, pin it down on a flat board, and with a broad camel's-hair brush, or a tuft of cotton wool, moisten its upper surface evenly with the following sensitizing solution. Of course, this must be done in the dark room :—

Bichromate of ammonia or potash	30 grains.
Phosphoric acid solution . .	1 fluid drachm.
Water	1 fluid ounce.

Hang up the paper in the dark to dry.

The phosphoric acid to be used in the above formula is the tribasic form, usually sold at the shops under the name of dilute phosphoric acid, which contains 100 parts of the acid dissolved in one ounce of water. If the acid obtained is too weak, the picture will be of a reddish tint; if too strong, it will be green. The best our obtainable is a deep purplish black, which can easily be got regulating the quantity or the strength of the acid.

When dry, place the sensitized paper in the usual way in the pres:e frame, under a translucent positive, if a positive copy be required, under a negative if *vice versâ*, and expose to light. The pro‑r time for exposure cannot readily be detected by lifting up part and examining it, except by a practised eye, because

scarcely a trace of a picture is visible after over-prolonged exposure. About one-fourth of the time for a silver print similarly lighted is needed.

The exposure completed, take the embryc picture into the dark room and develop it in the following manner. The development should be commenced within a few hours after exposure, because bichromate of potash combined with organic matter is a very unstable compound; and any decomposition arising from heat or otherwise may vitiate the whole results.

Development. For a picture 8×5 inches: pour into a flat porcelain or gutta-percha vessel, the bottom of which has been previously covered with a sheet of bibulous paper, one drachm of the ordinary commercial aniline, thoroughly mixed with two ounces of benzole. Attach the exposed paper by wafers to a piece of glass, or by pins to a flat board, the exposed face being upwards, and now place it downwards over the mouth of the tray in such a way that the embryo picture may receive and intercept the whole of the aniline vapour. The image quickly begins to show itself, and, as a general rule, if the exposure has been correctly timed, will be complete within an hour.

The same solution will develop many prints, but the development is quick or slow according to the amount of aniline present in the developer and the temperature of the air.

For large prints, Mr. Willis recommends that the exposed paper should be pinned to the bottom of a wooden box or chest, and the aniline mixture poured, to the point of saturation, into blotting-paper attached to the inside of the lid, which is then shut down and the developing vapour allowed to descend.

When the development of the image is complete, which can easily be seen by inspection, wash the print in plain water for two or three minutes, afterwards in water acidulated with a few drops of sulphuric acid. Remove the sulphuric acid by several washings in water, and dry the picture. It may then be mounted on thick cardboard if necessary; but in this printing process there is no reason why the picture should not be printed direct on the stiffest or coarsest cardboard, provided the upper surface is covered with a good white or tinted paper which suits the character of the print. The washing needs only to be superficial, to remove the soluble bichromate, which otherwise tints the ground of the picture to a dirty orange tone.

There are other modifications of this process now under investigation by Mr. Willis, which it is to be hoped may supersede the unsatisfactory silver processes.

Animal Charcoal. The product obtained by the carbonization of muscle, horn, blood, bones, and other animal matters. It is distinguished from vegetable charcoal by its lustre and sponginess. It is used in Photography to remove colour and organic impurities from solutions of nitrate of silver, &c. In commerce it contains phosphates and other salts derived from the animal organism, which, when it is added to nitrate of silver solutions, produce a yellow precipitate of phosphate of silver, and this often to such a degree as greatly to weaken the solution. Nitrate baths have been so weakened by it as to cause the iodide of silver entirely to peel off the plate on attempting to excite it. When purified it often contains hydrochloric acid, which precipitates white chloride of silver. It is called in trade ivory black, bone black, &c., and its impurities are always such that it is better to employ kaolin.

Animal Oil of Dippel. Has been employed as a solvent of bitumen in M. Niépce's processes. *See* "Bitumen." It is rectified oil of hartshorn, and is itself discoloured by solar light.

Animal Substances. The animal matters used in Photography are gelatine, albumen, gluten, isinglass, and a few others; they are of service both in forming transparent films, and in themselves combining with silver compounds for the production of images. They are substances with which English papers are sized, and hence pictures on English papers are redder in tone than those on the French and German papers sized with starch. *See* "Organic Matter."

Aperture. *See* "Lens."

Aplanatic (from ἀ, *without*, and πλάνη, *deviation*). Is a term used in Optics to denote a lens so constructed that spherical aberration is entirely destroyed.

Aqua Regia. Nitro-hydrochloric acid, *q. v.*

Aqua Fortis. Nitric acid, *q. v.*

Argentometer. Is a name given to a little instrument for measuring the strength of solutions of nitrate of silver. It acts on the principle of the hydrometer, and is so constructed and graduated that when allowed to float in a nitrate solution, the number of ᐨᐨains of nitrate of silver to the ounce of water is indicated by the ıber on the scale at the surface of the liquid. This instrument ɔcurate enough for the wants of the photographer.

ꞁut a more correct method of determining the strength of a ˀ of silver solution consists in precipitating an accurately-

measured portion of it by means of a carefully-proportioned solution of chloride of sodium, and then from the tables of atomic weights, calculating the percentage of silver present by comparing it with the weight of the sodium salt required to precipitate the whole of the silver as a chloride. Cheap apparatus, and the accurately-weighed pure reagent, with instructions how to use them, are sold at most of the dealers in photographic chemicals.

Arrow-root. Is the common name for the starch derived from the tubers of the *Maranta arundinacea*, by a process very similar to that by which starch is obtained from potatoes.

It is often much adulterated with potato farina, and other more objectionable substances. In its pure form it constitutes an excellent subsidiary sizing for photographic paper, giving a surface almost equal to ivory, and being in other respects useful in improving the tone of the image.

Artificial Light. In a photographic sense, artificial light is one by which negatives may be taken in the camera, or by which the different printing operations may be performed. The photographer may therefore avail himself of this actinic property of various kinds of artificial lights to work at night, or when daylight is too feeble for his purpose.

Of all artificial lights, that produced by the ignition of magnesium is one of the most actinic (*see* "Magnesium"). This metal can now be obtained of a pure quality, and at a cheap rate. It is generally sold in the form of wire, flat ribbons, or filings for illuminating purposes, and is used to a considerable extent in Photography. For the method of using it, *see* "Magnesium Lamp."

The electric light produced by a powerful galvanic battery, having wires tipped with charcoal brought into close proximity, is also highly actinic; but the light is very expensive, and is scarcely used.

A burning jet of the mixed gases, hydrogen and oxygen, under pressure, and brought to bear on a ball of lime, is much used in the enlarging process by development. *See* "Enlargements."

Common gas burners, Argand, oil, and paraffine lamps, are also used in photo-micrography, for printing on dry collodion plates, and for some other photographic purposes.

Various chemical compositions have been employed for producing, by their rapid combustion, an intense actinic light, acting during a few seconds only. They need not be particularized he

because they have now been almost entirely superseded by those mentioned above.

The effect of all artificial lights is greatly increased by placing them in the focus of a parabolic reflector, so as to throw the whole of their illuminating power on the object to be photographed.

Asphalt, Asphaltum, or Bitumen of Judæa. Is an indurated pitch, first found on the shores of the Dead Sea, in Judæa. It is now obtained in more abundance from Texas, Trinidad, Barbadoes, and other places. It is somewhat heavier than water, is easily melted, and very inflammable. It may be purified by boiling in water, when the pure asphalt floats on the surface, and the impurities subside; by the action of hydrochloric acid, which dissolves out the carbonate of calcium with which it is associated, or by dissolving the pure substance from the crude material by oil of turpentine.

It is the basis of most black varnishes, being soluble in several substances. It has also been used in some photographic processes, first by M. Nicephose Niépce, in his heliographic process, afterwards by M. Negre, of Paris, and Mr. Macpherson in photolithography, and by Mr. Pouncy in his carbon-printing process on paper.

Astigmation. (Greek, *α* privative, *στιγμη*, a point). A term used in Optics, to denote the want of a sharp point, or focus, in a pencil of rays.

Astro-photography. A convenient name for the application of Photography to the delineation of solar spots, the moon's disc, the planets and constellations.

Avoirdupois Weight. *See* "Tables of Weights and Measures" at the end of the volume.

Background. This is a screen placed behind the sitter in a photographic studio, or behind any object to be copied, in order to cut off the view of surrounding objects.

In photographic portraiture, the background is usually made of a frame of wood covered with canvas, painted in distemper, either plain, shaded, or scenic, or with a broad sheet of woollen stuff, without a seam, dyed with some colour. Scenic backgrounds are now manufactured to suit every conceivable variety of taste in the photographer, whether good or bad. On a matter which must be so purely one of taste, no rules can be laid down beyond this general one, which is pretty self-evident; viz., that no colour except some shade of grey should be used either for painting or dyeing the back-

ground; for where can be the use of introducing tints of red, yellow, blue, &c., which are not rendered truthfully in Photography by the corresponding shade, and which can only have the effect of misleading the eye of the artist? Of course, the background should on no account present a glazed surface.

Balance. A machine for weighing bodies. For practical photographic purposes a balance, in either of the scales of which a two grain weight will throw the beam, is sufficiently fine. Balances of this kind may be purchased at the photographic warehouses very cheaply.

Barium. A white and lustrous metal, which gradually oxidizes in the air.

Barium, Chloride of. $BaCl + 2\,HO = 122$. Is sometimes used for salting positive paper. It may be prepared by neutralizing diluted hydrochloric acid with the native carbonate of the same metal. By evaporation crystals of the chloride are obtained in flat, transparent, four-sided tables.

It has been stated that positive paper salted with chloride of barium gives a redder tone to the print than the other chlorides. This opinion may have arisen from the fact that it contains less chlorine, in the same weight of salt, than some others.

Chloride of barium is used as a test for sulphuric acid, with which it forms an insoluble compound. It will also detect two very common impurities in iodide of potassium; viz., a carbonate and a sulphate, by forming a precipitate in the solution.

Base. When a compound body possesses the property of neutralizing acids, whereby the distinguishing characteristics of both disappear, it is called a *base.* Oxygen is an element in almost all bases. A metal with oxygen forms an oxide often more than one of which are bases, and unite with acids. When a compound so formed is neutral, it is called a *neutral* salt; when not neutral, the salt is called *basic* or *acid,* according as the acid or base may be in excess. The salt is named from both the ingredients.

Bath. The vessel in which solutions are contained, when in use in photographic operations, is sometimes called a "bath." For all home purposes, glass is the best material for such vessels, because it does not contaminate the chemicals, and can be easily kept clean. The next best material is the "vitreous ware," manufactured by Messrs. Edwards & Son, of the Dalehall Potteries, Burslem. This is much cheaper, and at the same time much stronger than glass, and almost equally free from the risk of contaminating

chemicals. A material is used for baths in America which somewhat resembles Wedgwood ware, and appears to give general satisfaction; it is called "Photographic ware." The common white earthenware baths and dishes very soon acquire abraded surfaces; and in those spots where the glaze has been rubbed off or eaten away, the chemicals are acted on by the unprotected material beneath. For the purposes of the travelling photographer, pure gutta-percha seems to be the best material for baths and dishes, on account of its not being liable to be broken. The Gutta-Percha Company, in the City Road, supply a great variety of baths, funnels, &c., for photographic purposes, made of a sufficiently pure kind of gutta-percha. Ebonite is another material which has been used for baths. Messrs. Silver & Co. are the patentees, and have a manufactory of this substance on the banks of the Thames, opposite to Woolwich. It makes a hard, light, portable vessel, which does not seem to affect the chemicals contained in it, but is somewhat fragile under rough treatment. Papier-mâché has also been used for baths, but is not to be recommended. Wood coated with shellac is a cheap substitute for a better material, when the vessel is of large size.

All baths and trays should have the corners properly rounded, and no sharp angles left, in which dirt can accumulate. Glass baths should be solid, and not built up of pieces cemented together with marine glue, as these are very liable to come apart. Messrs. Edwards & Son manufacture many very useful kinds of baths and trays, of novel and ingenious design, to meet the varied wants of the photographer. They can be procured from any of the principal dealers in photographic goods.

Beaufoy's Acetic Acid. Is the acetic acid *fortiss.* of the Pharmacopœia. It is much cheaper and weaker than the glacial acid, and often contains impurities which do not unfit it for adding to the developer. It should not, however, be used in the paper processes for making aceto-nitrate of silver, or, if no other can be had, three times as much must be added as the formula for glacial acetic acid would indicate.

Beer Process. A collodion process, wherein the plate, after having been sensitized and washed in the usual manner, is dipped in or washed over with an infusion of malt or with beer. Plates so prepared may be preserved in the dark for a considerable time, and afterwards exposed in the camera, or they may, when dry, be used for producing positive transparencies by contact with a negative. The process has little to recommend it, except its simplicity.

Bellows Camera. A camera made to expand in the same manner as an accordion. The principle is good for some purposes, such as copying, but is not to be recommended for out-of-door work, because the instrument becomes liable to serious injury by being accidentally exposed to rain; the motion of its bellows side in the wind is also liable to detach particles of dust from the inside which may settle upon the film. The proper adjustments of a view camera are more difficult to apply when it is made on the bellows principle; and steadiness is thereby sacrificed. Nevertheless, the bellows form of view camera is a favourite with many amateurs; and Mr. Kinnear, of Edinburgh, has devised a form of it in which he seems to have made the most of the principle. It can be obtained from any of the leading camera makers.

Benzole, or Benzine. Is obtained in a pure state by distilling one part of crystallized benzoic acid with three of slaked lime. Commercially it is prepared on a large scale from coal naphtha, which contains it in abundance. It is a limpid, colourless liquid of an agreeable etherial odour, insoluble in water, but mixible with alcohol.

Benzole is used in dissolving many gums and resins for varnishes in Niepce's heliographic and Pouncy's carbon photographic processes, for dissolving bitumen of Judæa, and for some other purposes. It also dissolves caoutchouc and gutta-percha, forming solutions much used as a substratum for the collodion film in the dry processes, and for filling up the pores of positive paper previous to applying the albumen. The latter application has been patented by Mr. Sutton.

Berlin Ware. This is a kind of pottery marked with a blue stamp, and of such a quality as to resist the action of nitrate of silver, even when fused in it. Ordinary ware will not do for this purpose.

Binocular Camera. This is the name absurdly given to a stereoscopic camera fitted with a pair of lenses which are equal and similar in all respects, and have their axes parallel, and their centres from 2½ inches and upwards apart. The principle on which such a camera is constructed is perfectly sound; as will be seen by reference to the article on the "Theory of the Stereoscope."

Binocular Perspective Portraits; Binographs. This term has been applied to photographic portraits produced in a camera which is made to revolve in a horizontal plane through an angle, its axis being always directed to the same part of the sitter. It was supposed that in this way a single portrait could be obtained, which would exhibit the same *effects* of solidity as duplicate pictures

viewed in the stereoscope. This notion is, however, erroneous, as will be found explained in the article on the "Theory of the Stereoscope."

Binocular Vision. Vision when both eyes are employed. The term is used in contradistinction to monocular vision, in which only one eye is employed.

The effects produced by binocular vision are very remarkable. The subject will be found discussed at some length in the article "Vision."

Bitumen of Judæa. *See* "Asphalt."

Black Varnish. *See* "Varnish."

Blacking for the Inside of Cameras, &c. Of all things which have been tried for covering the inside of lens tubes, cameras, and other pieces of apparatus, nothing has been found so suitable as black cotton velvet. Tubes are sometimes blackened by a solution of bichloride of platinum in water, which precipitates platinum as a smooth black layer over the metal on which it is brushed. Sometimes bone black or ivory black is ground up with water and a little glue to a proper consistence, and applied as water colour to the surface. But both the colour and texture of black velvet are infinitely superior for this purpose to either platinum or charcoal; the pile of the velvet acting as so many little wells into which the light enters and is lost. Nothing takes a longer exposure than this, if it be desired to photograph it.

Blisters; Blistering. The formation of blisters in the film is a rather serious trouble, which occurs in some of the dry processes. It happens when the film, to which certain kinds of preservative have been applied, and allowed to get dry upon it, is wetted a second time in the development or subsequent washings. The blisters vary in size from a pin's head upwards, and are often very numerous. They do not occur with all kinds of preservative, and are most troublesome when albumen or gum arabic is employed. When a blister is formed in a film during development, it generally gets filled with the black liquid, and when dry leaves a black spot; but when formed during the subsequent washing or fixing, it merely leaves a small dark ring, denoting its boundary line, where it disappears on drying. One very good remedy for blistering of the film is to give the plate a preliminary coating of india-rubber dissolved in kerosolene, chloroform, or benzole. But it is better, if possible, to avoid the evil by going directly to the source of it, and so modifying the mechanical condition of the preservative

as to prevent its occurrence. The addition of ammonia to the albumen, in the Taupenot process, seems to have a beneficial effect, by rendering the albumen more limpid, and less horny when dry. Blistering is evidently owing to the expansibility of the film when wetted after being dried, and its non-adhesion to the glass in the spots where the blisters occur. A dried collodion film never blisters; nor does it when coated with tannin. It is some peculiarity of other preservatives which causes it to blister when impregnated with them. Heating the prepared plate strongly before the fire, as some persons have recommended, has no effect whatever in the prevention of blistering.

Blue Glass. The question whether blue or white glass is the best for the portrait-room has been frequently discussed. Blue glass increases the time of exposure more or less, according to the depth and shade of colour, but, on the other hand, it acts beneficially in modifying the glare of light which is sometimes injudiciously admitted into the glass room, and in this way relieves the eye of the sitter from a painful annoyance, which causes an unpleasant expression. Blue glass stained with cobalt is said to be very permanent in colour. White glass containing manganese is acted on by light, and becomes of a reddish tint, which is very objectionable.

Blue Meniscus. It has been proposed to use a blue meniscus instead of an achromatic lens for taking views, partly on the ground of economy, and partly because it was believed that a better picture might be produced. But these supposed advantages of a blue lens have not yet been demonstrated practically; on the contrary, a blue lens appears to have the disadvantage of increasing the time of exposure, and of yielding an inferior picture to that produced by an achromatic lens. This might have been expected; for an achromatic lens not only combines two of the coloured foci, but compresses together, so to speak, all the other coloured foci, some of which are more or less actinic. It seems impossible to obtain a satisfactory picture with either a colourless or blue meniscus, in consequence of their having no single actinic focus in which the principal actinic rays are collected. Besides this objection, no single lens can have its spherical aberration reduced in the same way as a compound lens can.

Blurring. A spreading of the dark parts of a negative over the lights. It is produced by pencils of light passing through the film into the body of the glass, and then suffering internal reflection at the back of it, and thus *acting again* upon the back of the film in a

different part. It occurs, of course, in both the wet and dry processes; but more generally in the dry, because the film is then more transparent, and does not so effectually impede the passage of actinic rays. The remedy for blurring is to paint the back of the dry plate with a non-actinic water-colour, which dries sufficiently transparent to allow you to watch the development of the picture through it; or, in the case of a wet plate, to lay a piece of wet red or orange coloured bibulous paper against the back of the plate, before putting it into the slide. If this precaution be taken, a class of subjects which, on account of the strong contrasts of light and shade which they exhibit, have offered much serious difficulty to the photographer, are brought more under his control.

Body. This term is applied to substances, in allusion to the quantity of stuff or substance which they contain; in meaning, it is opposed to thinness, weakness, transparency, and flimsiness. Hence we have papers without *body*, and with body; body colour in opposition to transparent colour; and photographs or pictures with no body, in opposition to those which have plenty of reduced material and of vigour.

Bowl Negatives. Negatives can be taken, by means of the panoramic lens, upon the segment of a sphere, including a hundred degrees of angle of view in all directions. Prints can be obtained from such negatives, either by a process of copying upon another bowl, by means of a panoramic copying lens placed at the common centre of both, or by laying a sensitive piece of silk upon the convex side of a suitable cushion, and pressing the negative into contact with it. In the latter case distortion is introduced in the picture when flattened out.

Bromides. Under this term is included a class of metallic salts which are of great importance in Photography. The most useful bromides will be described under the heading of their distinctive metals.

Bromine. $Br = 80$. Is usually extracted from *bittern* (the mother liquor which remains after crystallizing salt from sea water or salt springs) by the action of chlorine.

Bromine at ordinary temperatures is a brownish-red liquid, and very volatile, the vapour being poisonous. It is slightly soluble in water, more so in alcohol, and still more in ether.

In the daguerreotype process, it is used to give a much greater sensitiveness to the iodized plate than it would otherwise possess. For this purpose it may be used in an aqueous solution, or, prefer- · in the form of bromide of lime. *See* "Daguerreotype."

Bromised Collodion Process. *See* "Collodion Bromised."

Bronze in Photographic Printing. In many processes, both of sun-printing and development, the darkest parts of the impression assume after a time an olive-green colour, lighter than the dark brown which immediately preceded it. This has been called bronze, and its production bronzing. It occurs when the paper is rich in silver salts and organic matter, and especially when there is abundance of free nitrate and the exposure is prolonged. With very vigorous negatives to print from, this may be excessive, but there are means of preventing and also of remedying the extreme action. The paper must be rendered less sensitive, or the bronzing can be removed by chloride of gold and other means. *See* "Printing."

Brunswick Black. For the composition of this black varnish *see* "Varnish."

Buckle's Brush. The little article which passes by this name is made by pulling out some fine cotton wool by the fingers, which is then placed in a hook formed at the end of an annealed copper or silver wire, and drawn tightly into a suitable glass tube to serve as a handle. It may be used on albumen or paper surfaces, and is, in many respects, the most convenient method of applying chemical solutions. The solutions, when it is used, remain constant in their action, and the papers are more uniformly of the same strength; camel's-hair and other brushes are immediately destroyed by nitrate of silver; this brush may be hourly renewed.

Buff, and Buffing. A buff is used in the daguerreotype process for polishing the silver plate, and in the glass processes for polishing the glass plate. In the former process, it may be either a hand-buff or a buffing-lathe. The hand-buff is made of a piece of deal about sixteen inches long and five inches wide, having a handle at one end, and covered with velveteen, the fine ribs of which are laid *across* the buff. The buffing-lathe is a wheel in the shape of the frustrum of a cone, the axis of which is the axis of rotation, covered with wash-leather or doe-skin, and turned by the foot. Hand-buffs are generally kept in pairs, face to face, to prevent particles of dust from settling on the velveteen. The hand-buff used for polishing glass plates has a handle on the back, like a blacking brush, the front being padded, and covered with wash-leather.

To use the buffing-lathe, the wheel is put into rapid motion by means of a treadle worked by the foot, and the plate held against the leather. In using the hand-buff, the operator puts an old kid glove on the right hand, takes the handle of the buff in the left,

rests the end of it on the edge of a table, and lays the face of the plate on the velveteen; then, putting the fingers of the right hand on the back of the plate, he rubs it briskly backwards and forwards until it has received a sufficient polish; the plate being turned occasionally diagonally and crossways on the buff, and considerable pressure being employed.

A glass plate should first be rubbed dry with a cambric handkerchief, then laid on a pad of paper, and rubbed in every direction with the buff, until the dew from the breath condenses on it in an even sheet, without exhibiting marks or patches.

The plate, whether metal or glass, should be polished immediately before use, and the clean surface should on no account be touched with the fingers.

Burnishing Photographs. This operation is performed by rubbing the photograph, when mounted on cardboard, with a polished piece of agate set in a stick; the object being to give a finer surface and more brilliancy to the print.

Cadmium. Cd = 56. This metal in appearance much resembles tin, but in its chemical qualities it still more nearly resembles zinc, in the ores of which it is found. Zinc is the only metal more electro-positive than cadmium, and therefore the only one which will precipitate it from its solution in the metallic state. It is a scarce metal. Air and moisture scarcely act upon it, except it is heated; and this quality makes it valuable in Photography, because its salts in collodion are extremely stable, and in the crystalline state they have little tendency to deliquesce and oxidise.

Cadmium, Bromide of. Cd Br = 136. Occurs in acicular crystals or nacreous scales, and is formed by mixing bromide and filings of cadmium in water. The acicular crystals contain water, but when sublimed the bromide condenses in anhydrous pearly scales. It is preferred by many to the other bromides, for the same reasons as the corresponding iodide; viz., its stability, solubility, and purity.

Cadmium, Iodide of. Cd I = 183. This salt is obtained by heating filings of cadmium with iodine, or mixing them in a moist state. It crystallizes in large white six-sided tables, of a pearly lustre, which are fusible, and decomposed at a high temperature.

Iodide of cadmium is very soluble in water and alcohol. When pure, its alcoholic solution is permanent, and becomes discoloured very slowly and slightly by exposure to sunshine. Collodion iodised with iodide of cadmium does not become discoloured, or undergo any visible alteration by time, if kept in a cool dark place. This is

a great advantage; but, on the other hand, the nitrate of cadmium formed in the nitrate of silver bath is a salt which has an acid reaction, and its effects are similar to those produced by free nitric acid. The nitrate bath, therefore, gets gradually out of order when this iodiser is employed. The permanence of collodion iodised with iodide of cadmium is probably due to the difficulty with which cadmium is oxidised.

The common impurity of iodide of cadmium is iodide of zinc. When this is present the collodion becomes gradually discoloured; zinc being an easily oxidisable metal.

Iodide of cadmium impairs the fluidity of collodion.

Calcium. Ca = 20. An extremely oxidisable metal of which lime is the oxide. Little has been ascertained of its properties by actual experiment. Its compounds with the halogens are generally deliquescent, and prone to oxidise.

Calcium, Bromide of. Ca Br = 100. Obtained by digesting hydrate of lime in a solution of protobromide of iron, by heating lime in bromine vapour, or by dissolving carbonate of lime in hydrobromic acid. It is white and deliquescent, and its aqueous solution yields silky hydrated crystals. It is not so good as bromide of potassium for preparing sensitive papers for keeping, because the nitrate of lime formed is deliquescent, and keeps the paper moist, and therefore more prone to deterioration.

Calcium, Chloride of. Ca Cl = 55·5. This salt is generally prepared by dissolving chalk in hydrochloric acid. It is extremely soluble in water, its attraction for water being so great that it soon deliquesces in the air. On this account it is employed, when freshly fused, to deprive gases of aqueous vapour, and ether, alcohol, &c., of water. It is copiously soluble in alcohol, ten parts of anhydrous alcohol, sp. gr. ·794, dissolving seven of the chloride, the solution in cold weather affording crystals which contain sixty per cent. of alcohol instead of water of crystallization. It is not well adapted for salting positive printing paper, because the nitrate of lime which is formed is very deliquescent, and keeps the paper moist.

Calcium, Iodide of. Ca I = 147. This salt is obtained by dissolving carbonate of lime in hydriodic acid, evaporating to dryness, and fusing the residue in a close vessel. When this is dissolved in water and evaporated, it furnishes white deliquescent crystals.

Iodide of calcium is extremely soluble in water, and alcohol, even when absolute. *The alcoholic* solution is discoloured by light, and

collodion iodised with it becomes gradually reddened, as with the potassium salt. It is not much used for iodising paper or collodion, being inferior to some other iodides.

Calomel, or Subchloride of Mercury. $Hg_2 Cl = 235{\cdot}5$. This salt is formed in the positive collodion process when chloride of mercury in solution is poured over the picture. Ammoniacal gas blackens it, but heat restores the colour, and calomel remains unchanged; liquid ammonia decomposes it, and black suboxide of mercury is one of the results.

Calorific Rays. The heat rays of the spectrum. *See* "Spectrum." These rays, which reside principally at and beyond the red end of the spectrum, bear a strong analogy in some of their properties to the luminous and actinic rays. They proceed in straight lines, can be reflected from mirrors, refracted through lenses of rock salt, collected into foci, and polarized by various substances.

The calorific rays which proceed from *terrestrial* bodies are almost entirely stopped by glass; therefore the lenses used to produce the image upon a sensitive photographic tablet would, by intercepting those rays, prevent any action, injurious or otherwise, which they might produce if allowed to fall upon the chemicals composing the sensitive surface. Calorific rays, however, which proceed direct from the sun are *not* intercepted by glass; therefore the above remark does not apply to the case of obtaining a photograph of the sun's image formed by a lens. The examination of images formed by calorific rays, refracted through lenses of rock salt, and received upon various chemically-prepared surfaces, would be an interesting study, and might lead to the discovery of a new science, which might aptly be termed THERMOGRAPHY.

Calotype Process. (Gr. καλος, beautiful, τυπος, an impression). This is a negative process upon paper, and a very convenient one for the tourist, in which the paper is first prepared with a coating of iodide of silver, and then excited at any convenient subsequent time, by washing over it a weak solution of gallo-nitrate of silver. The following directions for performing the various operations are the result of considerable experience on the part of the writer, and lead to good results, with much certainty and uniformity, if are carefully carried out. But it must be remembered, as a that the calotype process, in which no bromide of silver occurs, nerally considered better adapted for well-lighted architectural ects than for views in which much dark foliage occurs. The ed-paper process is no doubt better adapted for the latter class objects than that now under consideration.

There are two different methods of preparing the paper with a coating of iodide of silver. The first is called the method by the *single* wash; the second, that by the *double* wash.

To argento-iodise the Paper by the Double Wash.—Float the face of the paper upon a bath containing 20 grains of nitrate of silver to the ounce of distilled water. Let it remain a minute or two on the bath, then hang it up to dry. Next immerse it in a solution containing 25 grains of iodide of potassium to the ounce of distilled water. Let it remain a minute or two in this solution, the exact time depending on the kind of paper employed, and requiring to be ascertained by experiment. If too short a time is allowed, the whole of the nitrate of silver is not decomposed, and the paper darkens in the light; if, on the contrary, too long a time is allowed, the iodide of potassium in the bath dissolves some of the iodide of silver in the paper. The time of sojourn in the iodide bath is therefore rather critical. On removing the paper from the bath, let it drain, and then immerse it in a pan of water, in which it must be allowed to soak, the water being changed several times, until the *whole* of the free iodide of potassium is removed. This soaking operation is rather troublesome, and the texture of the paper is decidedly injured by it. Should any excess of iodide of potassium remain in any part of the paper, it would decompose the weak exciting solution, and produce insensitive iodide of silver, and consequently a white patch in the negative. When the paper has been sufficiently washed, hang it up to dry. It is of a yellow primrose colour. When dry, it may be kept for use in a portfolio. It is not sensitive to light unless it has been *excessively* washed.

To argento-iodise the Paper by the Single Wash.—Lay the paper upon a board, with a piece of blotting-paper under it, and brush over it a solution called "double-iodide;" *i.e.*, a solution of iodide of silver in iodide of potassium (*see* "Double-iodide"). The best kind of brush is a large round one of camel's hair, bound with string or silver wire. Apply the solution copiously, both longitudinally and transversely, inclining the board, and keeping a flowing edge. Hang up the paper to dry in a room having a pure atmosphere, free from sulphurous and acid vapours, which bleach the reddish tint that the paper ought to assume. When very nearly, or even quite dry, immerse the paper in a pan of water as before, in order to remove completely the excess of iodide of potassium which it contains. Two or more papers should not be soaked in the same pan, but each paper should have a separate pan. When sufficiently washed—an operation which requires several hours—dry the paper, and put it away for use.

Argento-iodised paper may be kept for some weeks without losing its good qualities. Some persons affirm that it may be kept indefinitely in a dry place. It is said, on good authority, to be much improved by exposing it for an hour or two to strong sunshine.

In comparing the two methods of iodising the paper which have been described, it will be seen that the first is the most economical, but at the same time the least certain. A considerable quantity of iodide of potassium is wasted in the second mode of iodising, and the washing operation is rather more tedious.

The paper having been iodised by either of these methods, the remaining operations are the same, and are as follow :—

To excite the Paper.—Make two solutions, one a saturated solution of gallic acid in cold distilled water—which call solution A; the other, by dissolving 50 grains of nitrate of silver in 1 ounce of distilled water, and adding 1 drachm of glacial acetic acid—which call solution B. Immediately before use, mix, in a chemically-clean measure, 1 ounce of distilled water, 15 drops of solution B, and about as many drops of solution A, the number of the latter depending on the temperature and the kind of paper employed.

Lay the paper upon a board, with a piece of blotting-paper beneath, and apply this mixture copiously to it with a clean Buckle's brush (*q. v.*) Hold up the paper to drain for a minute, then blot off the surface moisture with clean blotting-paper, and put the sensitive paper into the dark slide.

The Exposure.—The average time of exposure, in a good light, with a lens of fifteen inches focus, and a half-inch stop, is seven minutes.

To develop the Picture.—Lay it upon a board, and brush over it, with a clean Buckle's brush, a mixture composed of 3 parts of solution A, and 2 parts of solution B. The picture, the darker parts of which are at first faintly visible, soon comes out of a fiery red tint. At this stage of the development it is necessary to check it, in order to obtain dense blacks instead of feeble reds in the darker parts of the negative. To accomplish this, brush over the picture, and complete the development with a solution of gallic acid alone.

Under this treatment the reds soon darken and intensify, and become eventually opaque blacks. The entire development should occupy about twenty minutes. It is an excellent plan, after having brushed on the gallic acid, to lay the paper face downwards upon a horizontal glass slab, on which a quantity of gallic acid solution has been previously spread.

To fix the Picture.—When the details are fully out, and the blacks of the proper intensity, wash the negative with water, and then im-

merse it in a solution containing 1 part of hyposulphite of soda to 4 parts of water. Let it remain until the whole of the yellow iodide of silver is removed from the paper. Then wash and soak it in water for several hours, changing the water several times, in order to remove the whole of the hypo from the paper. Lastly, hang it up to dry.

The negative is now finished; but, before printing from it, it is advisable to render it semi-transparent, either by waxing it (*see* "Waxing"), or by immersing it for a few hours or days, in almond oil; then wiping it and hanging it up for a week or two to dry.

There are one or two important points to be observed in this process :—

If the iodised paper is excited with a weak solution of aceto-nitrate of silver containing no admixture of gallic acid, it is quite as sensitive, or even *more* sensitive than before, but the negative is devoid of density, and the dark portions are grey, feeble and metallic. This shows the importance of introducing organic matter with the exciting solution. But the above effect does not take place equally with all kinds of paper. There is a coarse spongy kind of Whatman's paper, sized perhaps in a peculiar way, in which the gallic acid may be *advantageously* omitted in the exciting solution. If, on the other hand, too much gallic acid is added to this solution, the paper is liable to become brown all over, particularly in very hot weather. A good test of the proper state of the sensitive paper is to take a strip of it into the light. If it darkens instantly to a cold grey tint, incapable of being intensified by the further action of light, the negatives will probably be grey and feeble; but if it darkens to a red tint, which gets still darker by continuing the exposure, there is sufficient organic matter present to give a very intense picture.

It is of the utmost importance, in the calotype process just described, to use a paper which is not alkaline; and also to use pure trebly re-crystallised nitrate of silver, which is absolutely neutral to test paper. The English papers of Turner and Hollingworth are the best; and of these the thinnest sorts should be selected. They are sized with gelatine and alum, and have therefore an acid reaction. The foreign papers of Canson Frères, Rive, Marion, &c., are sized with resin dissolved in potass, and are therefore alkaline; the effect of which is, that from there not being enough acid in the feeble sensitising wash to counteract the alkali, they blacken all over in the development. A process by which Mr. Stuart has taken some of the most charming photographs upon paper which the writer has ever seen, and which has been erroneously called a calotype process, will be found described *under the* head of "Waxed Paper Process."

Cameo Portraits. Small portraits about the size of a cameo brooch, printed upon albumenised paper, mounted upon a card, and then passed under a press, which renders the surface of the print slightly convex. When four such portraits are mounted upon one card, diamond fashion, they are called "diamond cameos." Messrs. Window & Bridge are the patentees of this novelty.

Camera. (Latin, *camera*, a chamber). A dark box, in which the real image of an external object, formed by a convex lens, can be received upon a sensitive photographic tablet, which is at the same time protected from the action of all actinic rays which proceed from other sources.

There are many different kinds of photographic camera, adapted to the various requirements of the photographer, but we are only concerned here with discussing the *principles* on which such instruments should be constructed; the reader will then be able to judge for himself how far any camera which may be offered to his notice fulfils the required conditions. The cameras treated of in the present work will be found described respectively under the following heads:—"Camera for Views;" "Round-front Camera;" "Panoramic Camera;" "Pantascopic Camera;" "Stereoscopic Camera;" "Binocular Camera;" "Reflecting Camera;" "Camera for Portraits;" "Copying Camera;" and "Solar Camera" (*q. v.*)

The leading principles to be generally observed in the construction of a camera are, that it should be perfectly steady during the exposure, and that no light save that which actually forms the image should be permitted to fall upon the sensitive plate. The exceptions to the above general rule of perfect steadiness occur in a copying camera, in which the object to be copied is attached to the instrument; in a camera which is intended to follow the motion of a heavenly body; and in the pantascopic camera, in which either the plate or lens, or both, are moved by certain mechanism during the exposure. With these exceptions, a camera which cannot be made to stand steadily upon a firm support, or which can be easily made to vibrate perceptibly by a slight disturbing cause, is to be condemned. With respect to stray light falling upon the sensitive tablet, not only should every camera be light-tight, and have its interior surface lined or coated with some black, light-absorbing pigment, such as lamp-black ground with glue, or black velvet, which is still better, but it should be fitted with one or more perforated diaphragms, placed between the lens and the sensitive tablet, in order to intercept the light which, in spite of every precaution, would otherwise be reflected from the inner sides of the camera.

It may be well, perhaps, to mention that cameras have been devised for out-of-door work, in which the whole operation of taking a wet collodion picture is performed within the body of the instrument; and others in which the camera itself contains the nitrate bath, with the sensitive plate immersed until ready for use. Some good work has been done by Mr. Archer, and subsequently by others, in a camera of the former kind, but it was working under difficulties; and as for the latter kind of camera, the too prolonged sojourn of an iodised plate in the bath in which it is excited is a certain cause of failure. It is hardly worth while, therefore, to do more than briefly allude to such instruments in the present article.

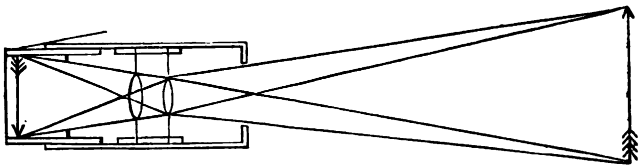
When the conditions of steadiness, and the prevention of stray light from falling upon the plate, have been satisfied, the other conditions of mechanical suitability for the purpose intended must be left to the photographer himself to decide on, according to his own taste and intelligence. In purchasing a camera, let him not be misled by its outward appearance, the beauty of its workmanship, the smoothness of its French-polished surfaces, &c., but let him rather consider whether judgment has been shown in the plan of it, and whether it will bear the unavoidable wear and tear of use, under a variety of trying circumstances not easy to foresee.

The material of which cameras are commonly made is well-seasoned Honduras mahogany, such as is used for coach panels. For the tropics, teak, however, appears to be still better. French polish is a great protection to the wood, and ought never to be omitted; but joiners rarely make allowance for it, and new work is too often affected by "sticktion." The perfection of good cabinet work is to fit well, and yet slide easily; but, above all things, the camera should be true to square and parallelism; and the plane of the ground glass should correspond exactly to that of the sensitive plate when in position. A patent was taken out some time ago for *metal* cameras, but they do not appear to have been largely used.

Camera for Portraits. This is generally made with a sliding body, when intended for half-plate or larger portraits. It is sometimes also provided with a swing back, so as to bring the feet as well as the head of the sitter into focus. There is no objection to its being made rather heavy, as it is not intended to be carried about. For small portraits of the card or cameo size, a special camera should be used to suit that purpose only; and it need not have a sliding body, as the focussing can be done by the screw in the mounting of the lens, or by a rack and pinion. Every portrait camera ought to be fitted with an internal diaphragm or screen, so as

to cut off reflected light from its inner sides. A great gain in the brilliancy of the image is effected by this simple means. Extreme steadiness is necessary in all small portrait cameras. The motion of the camera during exposure is much more injurious to the sharpness of the image than the motion of the object itself. For large portrait cameras the reflecting principle is strongly recommended. *See* "Reflecting Camera."

In the following figure is represented a portrait camera, with a sliding body, and projecting sides in front, in order to shade the lens, and give greater brilliancy to the image.



Camera for Views. Opticians are not to be blamed if they manufacture a great variety of view-cameras, in order to suit the whims of their customers; but it will be found that professional photographers, who take the largest number of good views, generally use a very simple kind of camera, suitable for the particular purpose which they require, and for that only. Amateurs should endeavour to follow, more than they usually do, the same sensible plan, and not haul about with them on their travels cumbrous and costly pieces of apparatus, which are contrived to answer many purposes, but to do no one thing properly. The view-camera, for pictures about 12 inches diagonal, should be rigid and strong, and made for plates about 9 inches square, with a holder, also, for plates 9 × 7, which can be inserted with the longest side either horizontal or vertical. There will then never be any necessity for putting the camera upon its side, to take upright views. In the top of the camera should be inserted a spirit-level, by means of which it can be adjusted exactly horizontal; and at each corner of the triangle, upon which the camera rests, there should be a screw by means of which the levelling of the instrument can be effected, after the legs of the tripod have been urely planted in the ground. The camera front should be fitted h a slider, which carries the lens, so contrived as to work either or down upon the segment of a cylinder, the central axis of which the line drawn across the centre of the picture. Inside the

camera there should be a screen or diaphragm for cutting off reflected light from the sides. The lens used should be one suited to the requirements of the case. There should be a single slide for wet plates, and three or more double slides for dry ones. The instrument will then be the most perfect that has yet been devised for taking photographic views of the size indicated.

An exceedingly useful form of view-camera for artists, for taking pictures upon a plate 7 inches square, which will either include a single view, covering the whole plate, or four small ones, each 3½ inches square, may be made on the same principle as the former one, but with the addition of the necessary removable internal partitions, and an extra flat front with four flanges. Instruments on this plan can be seen at Mr. Ross's manufactory. Only one lens is necessary, viz., a wide-angle DOUBLET of about 5½ inches equivalent focus. With two such lenses, however, two pairs of stereoscopic views can be taken upon the same plate. The addition of a portrait lens for instantaneous bits, or portraits 3½ inches square, will render the instrument as complete as an artist could desire to take with him on his rambles.

Camera for Copying. This camera is used for taking copies of photographs, prints, pictures, &c., either by reflected or transmitted light, and either of the same size as the original, or of a different size from it.

When the copy is to be less than one half the linear dimensions of the original, the ordinary camera, with a portrait or view lens, may be employed; but when the copy is to be nearly as large, or even larger than the original, some modifications must be introduced in the form of the ordinary camera, and also in the lens.

The principle to be borne in mind in copying an object on a different scale is this—that the linear dimension of the copy bears to the corresponding linear dimension of the original the same ratio that the distance of the copy bears to the distance of the original from the lens. For instance, let C be a certain linear dimension of the copy, and O the corresponding linear dimension of the original, and let U be the distance of the original from the lens, and V the distance of the copy from it. Then $C : O :: V : U$. (assuming, of course, that a single view lens is employed).

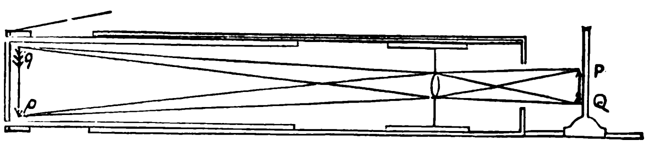
Hence we arrive at the following important conclusion, viz., that so long as the ratio $V : U$ remains constant, U may be increased as much as you please. Now, as the principal defects of photographic lenses proceed from the obliquity of the lateral pencils, and as the obliquity of these pencils is diminished in proportion as U is in-

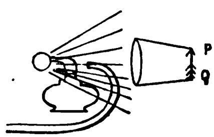
creased, it is evident that the lens should not be brought so near to the object to be copied as to introduce very oblique pencils, but that it should be placed at a distance from it equal to at least three times the longest dimension of the object to be copied, and be of sufficient length of focus to give an image of the required size.

In ordinary photographic work, pencils having an obliquity of from 17° to 30° are introduced, and the lens has to be so constructed as to meet this difficulty; but the form of lens best calculated for giving a flat field when pencils of great obliquity occur, is not that which at the same time gives the greatest distinctness of focus of the central pencils; that is to say, if the central pencils alone had to be corrected in the best possible way for spherical aberration, the form of lens which this condition would impose would not be such as to satisfy at the same time the conditions necessary for flatness of field when very oblique pencils are introduced. When, therefore, the necessity for obviating the defects due to obliquity is in some measure removed, the form of the lens may be such as to remedy more perfectly the defects of central pencils.

The best form of copying lens for enlarging purposes has yet to be devised. It will probably be found that a triple cemented lens resembling the object-glass of a microscope is the best form.

In copying a small photograph or print on a larger scale, the projecting front of the camera should be continued until it nearly touches the picture, and this should be illuminated as strongly as possible, either by the sun or strong diffused daylight. When artificial light is employed (the oxycalcium light, for instance), it may be brought very near to the end of the camera, and its light concentrated on the picture by means of a convex lens, as shown in annexed figure.





Whenever the light is sufficiently intense to allow of a stop being used, it should certainly be introduced as a remedy for the unavoidable defects of the lens. When an achromatic convex lens is used, like that in the figure, the stop should be placed immediately in contact with it, either in front or behind.

Small bas-reliefs may be copied in this way very successfully, by throwing the light obliquely on them, and using a reflector to diminish the intensity of the shadows. It is generally found difficult in practice to place the plane of the sensitive surface accurately parallel to the plane of the picture to be copied, but unless this is done, the lines of the copy are distorted. Where the original is small, it may be placed on a holder connected with the bottom of the camera, as shown in the figure; but, if this is not possible, the end of the sliding part of the camera should be fitted with the arrangement employed in the ordinary camera, for allowing the plane of the picture to be inclined at any small angle to the axis of the lens. By means of these adjustments, any distortion of the image on the ground-glass may be easily remedied.

When the picture to be copied is transparent, it should, if possible, be inserted within the camera, the front of which should be sufficiently lengthened to receive it; and the light which is transmitted through it should either proceed from the sky, or a large white illuminated disc, or an artificial light placed behind a condenser. When practicable, the sky should always be used as a luminous background, in preference to any other kind of light. When the sky is used as the source of transmitted light, the instrument may be mounted on a stand, in such a way as to turn on an axis, to permit of its being directed to any part of the heavens. When the copying camera is placed with its axis vertical, the free nitrate on a sensitive plate does not drain towards the lower part, and the picture is consequently more uniform in density. Whenever it is practicable, therefore, to point the instrument towards the zenith, this should certainly be done.

Having now explained the *principle* of the construction of a copying camera, it will be unnecessary to enter further into detail, as the operator will find no difficulty in modifying his arrangements to suit any particular case.

Camphor. A concrete essential oil obtained by distillation from the camphor laurel of China and Japan. It is sometimes added to albumen, gelatine, tannin, and other organic solutions used in Photography, to prevent them from decomposition. This effect which it possesses is probably due to its absorbing the oxygen which would otherwise act on such solutions.

Canada Balsam. This is a kind of turpentine obtained from the *Abies balsamea,* which grows in Canada and the State of Maine; it is used to cement the lenses which form an achromatic combination, in order to diminish the reflections at the inner surfaces. When thus employed its colour is not found appreciably to stop the actinic rays. It is also used for mounting microscopic objects, and for some other purposes.

Caoutchouc. Common india-rubber, the inspissated milky juice of certain trees growing in America and the East Indies. Various plate-holders, and other pieces of apparatus, are made in part or wholly of this material; but if it is to be brought into contact with nitrate of silver solutions, it should be remembered that the very flexible and elastic variety called vulcanized india-rubber, contains sulphur, imparted to it in its manufacture. It is soluble in ether, chloroform, benzole, and some volatile and fixed oils. Naphtha also dissolves it, with the aid of heat. In some brittle black varnishes, where these solvents are resorted to, caoutchouc, in small quantity, is a useful ingredient.

Cap of the Lens. The brass, or, what is better, pasteboard cover, which is used to cover and uncover the lens at the time of exposing the sensitive plate to light.

Capsules. Small shallow basins made of berlin ware, platinum, &c., for evaporations, solutions, &c.

Carbon. $C=6$. An elementary substance appearing in a great variety of forms, of which the diamond is the purest and charcoal the most common. A stick of charcoal put into a solution of nitrate of silver and placed in the sunlight, will reduce pure white silver around and adhering to itself. It has hence been said that carbon, with the aid of light, can reduce silver in solution to the metallic state; but the reduction is due rather to the peculiar physical properties of carbon in certain forms, than to an ordinary chemical reaction. This effect of carbon rather resembles the catalytic action of spongy platinum. It is present in all organic bodies.

C—bon, Bisulphide of, $C\ S_2=38$. Is a volatile, transparent, —ammable liquid of great refractive and dispersive power. It —ent of sulphur, and is therefore sometimes used to determine — the yellow colour of a photograph is due to sulphur.

—onates. Are salts which contain carbonic acid. The —tes used in Photography, when soluble, are alkaline in their —ies; and this must be remembered, because an excess added —id solution containing a stronger acid, in order to

neutralise it, renders the solution alkaline. When hard water containing carbonate of lime is used for making nitrate of silver baths for negatives, the solution will be alkaline; and positives should not be washed in such hard water immediately after passing through solutions containing carbonate of soda—a toning-bath, for instance —or the lime will be precipitated on the surface. It is better to place them at once into the hyposulphite of soda fixing-bath.

Carbonic Acid. $CO_2 = 22$. Is a very heavy and feebly acid gas, most readily prepared by displacing it from any of the carbonates by a stronger acid, when it escapes with effervescence. Its effect in restraining a developer is almost inappreciable.

Carbonized Plates. Copper plates have been evenly covered with hydrocarbon, in the form of finely-divided powder, and by exposure to heat, have been superficially converted into carburet of copper. These plates, covered with nitrate of silver and exposed to light under a negative, will receive an image in pure milk-white silver; but there is always too much tendency in the metallic plates themselves, to reduce the nitrate, to render the process available.

Carbon-Printing Process.—Beauregard's. M. Testud de Beauregard took out a patent in England, bearing date December 12, 1857, for an invention which consists in producing photographic prints by means of carbon or other colouring matter, applied by superposition to a coating sensitive to the action of light. The following are the particulars stated in his specification:—

"Paper is immersed in or floated upon a warm solution of bichromate of potass or ammonia, mixed with gelatine. It is then dried, and its surface covered with the pigment. The pigment may be rubbed over the dry surface with a pad of leather or other suitable material; or it may be ground very fine with nut-oil, or other oil, and rubbed over the surface, which is subsequently immersed in a bath of ether, to which a little collodion may be added; or the paper may be immersed in a bath of Indian ink or other pigment, ground up very fine with water and mixed with gelatine, and a little gum or dextrine, and used hot; or rollers, or presses, or other apparatus may be employed to apply the pigment or assist the operation. The paper having been prepared in the dark, is exposed to the action of light, and washed in hot water. This dissolves the gelatine which has not been acted on by the light, but does not dissolve that which has been rendered insoluble by the action of light, and which insoluble gelatine retains the pigment, and thus produces the image. Glass, or other substances, may be substituted for paper. By employing carbon, pigment, or finely-

divided gold or silver, photographs or pictures of the greatest permanence and durability may be obtained."

Carbon-Printing Process, Pcitevin's. M. Alphonse Louis Poitevin took out a patent in England, bearing date December 13, 1855, in which he vaguely describes a process by which a carbon print may be obtained. There is, however, no evidence to prove that he ever exhibited a carbon print taken by his patented method, before Mr. Pouncy had exhibited prints taken by a similar method, reduced to an exact formula. The following is an extract from M. Poitevin's specification:—

"I apply various liquid and solid colours upon paper, cloth, glass, and other surfaces, by mixing such colours with a mixture composed of equal parts of a concentrated solution of albumen, fibrine, gum arabic, gelatine, or similar organic substance, and a concentrated solution of bichromate of potass, or of any base which does not precipitate the organic matter of the first solution, and applying this new mixture or combination to the paper, or other fabric or surface.

"The photographic impression is produced upon this prepared surface by the action of light passing through a negative photographic picture, or an engraving or other suitable object, or screen, or in the camera obscura, and it is then washed with a sponge and a large quantity of water. The albumen, or other organic matter, is rendered insoluble at the parts where it has been acted on by the light, and the design is thus produced in the colour which has been employed. Mixtures containing different colours may be applied to different parts of the surface, corresponding to different parts of the negative or screen employed to produce the photographic impression. A design in several colours may thus be produced. The proportions of the materials may be varied.

"What I claim as new is the mode of printing upon paper, cloth, glass, or other suitable surfaces, by applying to them a mixture of liquid or solid colours, with the aforesaid chromatized albumen or other organic matter, and exposing to light as hereinbefore mentioned, and afterwards washing away those portions of the mixture which have not been acted upon by the light, as hereinbefore described."

Carbon-Printing Process.—Pouncy's. The following are the printed directions for the above process, which were first published by Mr. John Pouncy, of Dorchester, through the medium of *Photographic Notes*, of January 1st, 1859. It appears to be the first definite process by which presentable carbon prints were produced;

and Mr. Pouncy received for it a silver medal, and a prize of four hundred francs from the French Photographic Society :—

"1. Prepare a saturated solution of bichromate of potass.

"2. Prepare a common solution of gum arabic, about the consistency of thin varnish.

"3. Prepare vegetable carbon, by grinding it with a muller on a paint stone or slab, in the same manner that a painter grinds his colours; and be careful that it is ground very fine. It is to be ground with water.

"4. Mix together equal parts of solutions (1) and (2), say four drachms of each to the ounce, and then add one drachm of No. 3.

"5. Stir the whole well together with a glass rod, and strain it through the finest muslin that can be obtained.

"6. Now apply the prepared solution in the following manner :—Lay the paper, face uppermost, on a glass slab, or a very level and smooth board; the glass is the better of the two. Commence coating freely with a broad camel's-hair brush, laying on a copious supply over the whole surface; and then allow the paper to absorb for about two minutes.

"7. This done, remove the superfluous liquid thus :—Take a painter's four-inch hog's-hair 'softener,' and work it regularly over the paper, with an alternate vertical and horizontal motion, until the whole presents a smooth even surface, partially dry. The drying may then be completed by the fire.

"[Operators will of course have inferred that the whole of these operations must be carried on in a dark room. They should also be informed that any other method of application, including floating, &c., will prove ineffectual.]

"8. Expose in the usual way, varying the time according to light, say about four or five minutes in the sun, and from ten to fifteen in the shade. This, however, will be affected by the intensity of the negative, time of year, &c.

"9. On removal from the pressure-frame, lay the picture, face downwards, in a flat dish of clean water, taking care to exclude all air-bubbles. It will be found advisable to place some slight weight upon the picture, that the back may thus be retained wholly under water and kept free from stains. The time of soaking may be roughly stated at five or six hours; though in some cases of over-exposure, pictures may remain in the water for days, and come out equally good.

"It may be observed here, that when the high lights of the picture appear soon after immersion, the operator may conclude that he has *under-exposed*, or that his gum arabic is too thick, which

last fault may be corrected by the addition of a little more bichromate. It is preferable to find the picture developing evenly all over. Each picture must be in a separate dish, and finally washed under a gentle stream of clean water from a tap or a lip-cup. Should the margin be not quite clean, pass a camel's-hair brush carefully over it before rinsing from the tap, and if needful, any parts of the picture; but the best results are obtained by soaking only."

More recently Mr. Pouncy has entirely remodelled his system of carbon printing, which in his, as in all other attempts at that period, consisted in laying the blackened side of the paper against the negative, instead of the white back. This was pointed out by Mr. Blair, of Perth, in a long and interesting letter to *Photographic Notes* of February 1st, 1859. It is almost self-evident that, in order to reproduce the gradations of shade in the negative, the light must act first upon the *back* of the sensitive film, and not upon its face.

Mr. Pouncy now uses bitumen of Judæa, instead of a bichromate and gum, as the sensitising agent. He dissolves this substance in benzole, and intimately mixes it with lithographic ink, or other greasy colouring matter. He applies this, by means of a brush, to a piece of thin "bank post," rendered transparent with poppy oil. When dry, the *back* of the paper is placed in contact with a negative in the printing frame, as usual. The time of exposure to light varies from five to twenty minutes, according to its intensity. The picture is then developed by immersing it in turpentine or benzole, which washes away all the superfluous colouring matter, and the bitumen which has not been affected by light. The developed picture is then coated on the carbon side with a sticky varnish, and attached by pressure to a mounting board. The thin paper support of the bitumen is now uppermost; but it may be removed by damping it with a sponge dipped in warm water, leaving the pigment firmly attached to the mounting board.

Instead of carbon, ceramic pigments, or metallic oxides, may be mixed with the bitumen, and the whole transferred to "potters' biscuit," and burnt in as usual.

Carbon-Printing Process.—Salmon and Garnier. This process consists in first applying to a sheet of paper, or any other suitable surface, a sensitive mixture composed of organic matter and [illegible]romate of potash, then exposing it to light under a negative— applying carbon, or other pigment, in powder, to the exposed [illegible]e—and then immersing the whole in water. Wherever the [illegible] has acted the powder sticks; but from the parts where it has not

acted, the powder comes off along with the unaltered sensitive mixture. A picture is thus produced by means of the pigment employed.

Carbon-Printing Process.—J. W. Swan. In this process, by which the finest carbon prints that have yet been seen were taken, a glass plate is coated with plain collodion, and to this film is then applied a sensitive layer, composed of gelatine, bichromate of ammonia, sugar, and finely ground Indian ink. When this is dry, the film is stripped from the glass, and the collodion side exposed under a negative for about one-third the time required for a silver print. You cannot, however, tell by inspection whether the exposure has been long enough or not. The exposed film is then fastened, by a solution of starch, to a piece of paper or card, collodion side downwards, and the picture is developed by placing it in warm water, which clears up the lights by removing the gelatine layer that has not been acted on by light, and with it the carbon which it contains. The picture is, of course, reversed, and the negative must be taken with its back towards the lens; or, if this is not done, a double transfer is required, and india-rubber paste must be used instead of starch. The finished print is, of course, glazed with the film of collodion in front.

Carbon prints taken by the above process are as fine in gradation, vigour, and sharpness, as the best silver prints. There seems, however, to be some risk of their destruction, in consequence of the collodion film cracking. The process is patented, and the patent (No. 503) bears date February 29, 1864. Some specimens submitted to the public by the patentee are not inferior to the very finest photographs upon paper that have ever been seen.

Carboy. A large globular vessel of glass, surrounded by wickerwork to protect it.

Card-Portrait. A small portrait mounted upon a card, measuring $4\frac{1}{8}$ by $2\frac{1}{2}$ inches.

Carrageen, or Irish Moss. Is a kind of seaweed containing a jelly, which has been used for re-sizing positive photographic paper, and for mixing with the iodizing solution for the waxed paper process.

Carte-de-Visite. An absurd name given to a small portrait.

Caseine. Constitutes the chief nitrogenized substance in milk. It resembles albumen in most of its properties, and has been used with good effect in the waxed paper negative, and in some printing processes on plain *salted paper.*

Castor Oil. This oil is extracted from the seeds of *Ricinus communis*, or *Palma Christi*, which is cultivated in warm climates. In Photography castor oil has been used conjoined in small proportions with collodion, for the purpose of conferring better flowing properties and greater adhesiveness; but this is only necessary when the collodion contains a considerable quantity of water.

Catalysis, or Chemical Action by Contact. Is a term applied by chemists to that process in which a substance, by its mere presence, and without being itself changed, induces decomposition of another body with which it is brought in contact. For instance, when starch is boiled for some time in water acidulated with sulphuric acid, the sulphuric acid itself remains unchanged, but the starch is converted into sugar. This effect would not take place without the presence of the acid. It has been attempted to explain some obscure photographic phenomena by catalysis.

Catalysotype. A process invented by Dr. Woods, in which the paper is first prepared with syrup of iodide of iron, instead of the ordinary iodide of potassium. As the picture developes itself after exposure by merely keeping the paper moist without using the usual gallic acid developer, it was supposed that light set up a "catalytic" action on the silver salt, which then operated on the iron salt to produce a picture. The truth was, that when the paper was excited on the nitrate of silver, protonitrate of iron was formed by the same decomposition which produced iodide of silver, and this protosalt is a still more energetic developer than gallic acid. The process is not good, because the solution of nitrate of silver used for exciting is in a few hours quite blackened by the iron, and the iron-syrup is itself very inconstant in its composition; but with smart manipulation and fresh solutions it is extremely quick.

Caustic. (Gr., καυσις, burning). Chemical substances which destroy the vitality of any part of the body, or produce effects like burning, are called caustic. The name is generally applied to certain alkaline oxides and acid salts, which destroy animal structure. The most commonly used caustics are nitrate of silver, and potassa. The fixed alkalies and earths are all caustic, as lime, baryta, potassa; also such salts as chloride of zinc and chloride of gold.

Caustic Curve; Caustic Surface. These are terms used in optics. When a pencil of rays, after refraction through a lens, or rexion from a mirror, is affected by spherical aberration, the locus the ultimate intersections of the rays which cross each other con- hat is called the "caustic surface;" and a plane section

of that locus, passing through the axis of the pencil, is called the "caustic curve." The "primary focal line" is situated on that curve.

Cellulose, or Lignin. This substance constitutes the walls or the solid framework of plants. The purest natural form in which it can be obtained is cotton, linen, or hemp, and in this shape it is used in Photography for the manufacture of pyroxyline.

Cement. This term is applied to any substance having the property of holding together the surface of two bodies by means of adhesion. Many glutinous and resinous cements are used in Photography; but it would occupy too much space to particularise them and their uses here.

Centigrade Thermometer. This is the thermometer generally used on the Continent, and is so called because the space between freezing and boiling water is divided into 100 degrees. The thermometer used in England is Fahrenheit's, where freezing water is marked 32°, and the boiling point 212°. In the two scales, therefore, 32 and 0, 41 and 5, 59 and 15, 68 and 20, 86 and 30 are corresponding points. To convert centigrade into Fahrenheit, multiply by 9, divide by 5, and add 32.

Centigramme. A weight often introduced into England with French formulæ. It is the hundredth of a gramme. A gramme is equal to 15·432 grains troy, and a centigramme to ·1543 gr.

Centilitre. The hundredth part of a litre, or of 35 oz. 2 dr. 11 min. English fluid measure.

Centimetre. The hundredth of a metre, or of 39·7 inches English; it is nearly $\frac{4}{10}$ or $\frac{2}{5}$ of an English inch.

Chalk. A soft form of carbonate of lime. It is sometimes used in the photographer's laboratory for polishing glass plates, and for neutralising substances which contain an excess of a free acid more powerful than carbonic.

Chamois or Wash Leather. Is extensively used for cleaning glass plates; but before it is fit for this purpose it must undergo a preliminary preparation as follows. Soak the skin in a cold solution of common washing soda for twelve hours. The object of this is to neutralize the oil used in the preparation of the skin. Then soak the skin in many changes of cold water, wringing out between each change, till the water is no longer discoloured when wrung out. Hang up to dry, but not in too warm a place. When dry, the cleansed leather will be somewhat hard and unpliable. Roll it up

and beat it with a wooden mallet, after which it will remain soft and pliable. Nothing can be better suited for giving a finishing polish to glass plates than wash-leather so prepared. Keep the leather when not in use in a dry cotton bag.

Charcoal. *See* "Animal Charcoal."

Chiaroscuro. Literally, *light dark.* Is a term applied by artists to the proper balancing of light and shade in a picture. Rembrandt's works are often masterly illustrations.

China Clay. *See* "Kaolin."

China Ink. Is a finely-divided carbon made into sticks with gelatine. The finest kinds come from China, and the preparation is kept secret.

Chlorates. Are compounds of chloric acid with a base. They are chiefly interesting as sources of oxygen.

Chlorides. This term is generally used to designate those compounds of chlorine which are not acids. There are, however, perchlorides of some of the metals which are decidedly negative to the alkaline protochlorides, and form with them definite and permanent salts. The terchloride of gold, for example, forms with chloride of sodium, the auro-chloride of sodium, much used in the photographic toning processes.

The different chlorides useful in Photography will be described under the headings of their respective metals or bases.

Chlorine. $Cl = 35 \cdot 5$. Is a greenish coloured gas, discovered by Scheele, in the year 1774. It occurs in very large quantity in common salt, but it is generally isolated by the action of peroxide of manganese on hydrochloric acid. The gas itself has not, as yet, been found of much practical use in Photography; but, as some of its combinations are extensively employed, we have given it a passing notice here.

Chloroform. $C_2\ HCl_3 = 119 \cdot 5$. Was discovered in 1831, by Goubeiran. It can be prepared by several methods; but the most economical, and the one generally employed, is by the distillation of alcohol with chloride of lime. It has been used to enhance the limpidity and sensitiveness of collodion; but it is very doubtful whether it really confers any benefit on that substance. Chloroform, however, is a very powerful solvent of several resins, gutta-percha, caoutchouc, &c. It also extracts from amber a resin which forms a varnish for collodion negatives or positives. This varnish does not

require the aid of heat for its application; but it does not form so protective a surface as some other less expensive preparations.

Chondrine. Is a form of gelatine prepared from cartilages. It differs from ordinary gelatine, in being precipitated from its aqueous solutions by almost any acid. From the fact of its being prepared from animal organisms, like the other, this substance is often found conjoined with gelatine, and, photographically speaking, constitutes an impurity.

Chromates and Chromic Acid. Chromic acid is a teroxide of chromium $CR\ O_3$. It is decomposed instantly by the contact of organic matter, which takes part of the oxygen with alkali metals; it forms two kinds of salts, the neutral and the acid chromates. The latter are called bichromates, and they possess powerful photographic properties when conjoined with certain organic substances, such as gelatine, &c. The *rationale* of the action of chromic acid, and of the bichromates, in the presence of organic matter, is shortly this:—Light sets free oxygen, which unites with the gelatine, &c., thus forming a resinous and insoluble compound; it also deepens the colours, because of the formation of a sesquioxide. The practical application of their properties to photographic purposes will be described under the headings of the different processes in which chromic acid is used.

Chromatic Aberration. *See* "Aberration."

Chromatype. A name given to that class of photogenic decompositions in which chromic acid is partially deoxidized. The following are some of the modes adopted for getting photographs by the chromium salts:—

(*a*) Soak the paper in a saturated solution of bichromate of potash, and dry it by rapid agitation in front of a brisk fire out of the light. It is now of a bright yellow colour, but exposure to the sun under a negative will produce a positive, by darkening the exposed parts to a deep orange colour. Washing well in water removes the unchanged yellow salt from the lights, but the reduced sesquioxide in the shadows remains combined with the paper. The paper should be well sized, or the bichromate will be only feebly decomposed.

(*b*) Brush a sizing of starch very uniformly over the paper, and then steep it in a weak alcoholic solution of iodine, and if the coating of blue iodide of starch be not uniform, repeat the operation. Steep it in bichromate and dry it as before. The print will be negative, even, from a negative, *and positive* from a positive, if after exposure

and washing it is again steeped in the solution of iodine, which renders the *unexposed* parts of a dark violet colour.

(c) To a saturated solution of bichromate of potassa, add a saturated solution of sulphate of nickel, in quantity more than sufficient to decompose the whole of the bichromate, or 1 drachm of the latter (the potassa) in crystals to 2 drachms of the former, also in crystals. Apply this to the surface of the paper and expose under a negative. The exposed parts become brown and the rest remain yellow, and if now washed in water the result is a positive picture. But if the exposure be continued under the negative beyond the dark stage the browning disappears and the exposed parts are white, a colourless double salt being formed there. When nitrate of silver is applied as a developer, the chromate of silver is deposited in the unsunned portions, where the original solution remains unchanged, but not on the whitened parts. Pure water will remove nearly all except the precipitated chromate, which, if thought desirable, may be converted into chloride, and exposed again, and developed as in the usual silver processes. Sometimes the colourless double salt formed will decompose the nitrate of silver, owing to its imperfect formation. The chromate of silver, by which the shadows are represented, is itself decomposed by light, and, therefore, must be changed in some way, before permanence is attained.

(d) Dissolve neutral chromate of copper in ammonia. The solution, which is now a mixture of chromate of ammonia and of ammoniacal solution of oxide of copper, is of a green colour, formed by the mixed yellow and blue of the separate solutions. Papers prepared with this behave like those soaked in the chromate of copper.

Chrysotype Process. (Gr., χρυσος, gold). This is one of Sir John Herschel's ingenious processes. The operations are as follow:—

First. Immerse a sheet of paper in a *moderately* strong solution of ammonia-citrate of iron, and dry it in the dark. The strength of solution should be such as to dry into a good yellow colour, not ill brown.

Second. Expose the paper to light, either in the camera or pressure frame, under a negative, until a very faint impression is obtained.

Third. Brush over the paper a neutral solution of chloride of gold, of such strength as to have about the colour of sherry wine. The picture immediately appears, and is rapidly developed to a

Wash the developed print in several changes of water,

and fix it with a weak solution of iodide of potassium: then wash again thoroughly, and dry.

The picture is now finished.

Circle of least confusion. The nearest approach to a focus of a pencil after oblique reflexion or refraction. *See* "Focal Lines."

Citric Acid is derived from the juice of lemons and other fruits. The juice is made to undergo a fermentation; it is then neutralized with lime, by which citrate of calcium is formed. From this the acid is liberated by means of sulphuric acid.

Citric acid is a powerful retardent to the reduction of silver salts by means of a developer. Hence it is found serviceable to add it to the pyrogallic solution used as an intensifier for negatives, developed with protosulphate of iron. It tends to keep the deep shadows very clear, and prevents abnormal reduction of the silver.

A small proportion of citric acid may be added with great advantage to the nitrate bath for positive paper, when there is too much tendency exhibited by the paper to print of a slaty tone.

Cleansing. The cleansing of bottles, papers, stirring rods, and apparatus in general, is a matter of essential importance in many photographical operations; and the great rule must be to clean immediately after use, when purity is obtained with much more certainty and much less labour. All dirty glasses, &c., should be immediately put in a particular place and attended to at the first leisure moment. The following directions will be found useful:—

(*a*) *To clean Albumen from Glass Plates.* Use a solution of caustic potash, or ammonia, for albumen is soluble in alkaline solutions; then wash with water; and lastly, with dilute nitric acid and plenty of water.

(*b*) *Collodion Bottles.* Leave the stopper out until the ether and alcohol have evaporated, and the film is hard and horny, when it will be easily removed, without any adhering to the glass, by means of cold water and a bottle brush. Drain and rinse out with a little alcohol.

(*c*) *Developing Measures and Trays.* Wash well with tow, or a rag and common water, then with a little strong nitric acid if the black precipitate has dried in the vessel. The acid should remain some time in contact with the blackened parts, even after they appear clean: lastly, plenty of water and a clean dry cloth.

(*d*) *Gallic Acid and Gallo-Nitrate.* Bottles in which gallic acid has been allowed to become discoloured or mouldy require the use of nitric acid, which decomposes most organic matters, before they are fit to receive solutions of other compounds.

(*e*) *Glass Plates and Vessels.* These should be washed and rinsed, if possible, as soon as they are done with, and before they have got dry: even common water, if allowed to dry on them, will leave matters which often require considerable force to remove. If plain water will not clean them, a little tow and the ashes from the fire will generally remove everything. Sand or gravel should not be used with white glass vessels, since it always scratches the soft flint glass of which English vessels are made. They must after washing be rinsed, drained, and wiped with a clean coarse cloth. New window glass or crown glass requires particular care in cleaning, especially in hot weather. Glass plates which have received pictures before are, contrary to the general opinion, better than new, if carefully cleaned after each experiment. Nitric acid with or without tripoli is the best detergent for new glass: better without tripoli, if possible. If a plate be cold, and then take the breath in an even film, it is clean. If a collodion picture has been developed with pyrogallic acid, it requires only water, but if with an iron salt, nitric acid will be necessary.

(*f*) *Grease.* Greasy glasses should not be washed, but, in the first place, wiped with tow, to remove as much as possible of the grease, and then a dry cloth should be used until the surface appears clean. It should afterwards be washed with nitric acid, or caustic potassa and tow, which removes the thin film of grease remaining, and it may then be rinsed, drained, and wiped as before. A special duster should be appropriated to remove grease.

(*g*) *Lenses.* Do not use silk, for it is apt to scratch: a soft wash-leather, free from the powders used in cleaning it, is best; if the lens be greasy, soft tissue paper will clean it quickly, especially if moistened with a little alkali. Rub off the alkali with fresh paper, and finish with the wash-leather kept for this purpose.

(*h*) *Nitrate of Silver Stains.* Nothing is so good as nitric acid for porcelain or glass. For linen, or the hands, mix together alcohol 10 ounces, iodine ¼ ounce. Apply a little to the stain, and when it has become yellow, dissolve it out with cyanide of potassium, and wash well.

(*i*) *Papers containing Metallic Spots.* Make two solutions, one of one ounce of tartaric acid in 10 of water, and the other of one fl. ounce of liquor ammoniæ in 20 ounces of water. Let the papers soak in the first for a quarter of an hour, one over the other, then ˈ̵ce them for a few minutes in the second. Rinse in plain water hang up to dry. The metal is removed as ammonio-tartrate.

) *Resinous, Bituminous, and Tarry Varnishes.* As much as ible should be scraped off with a knife; then use tow, with a

little strong caustic potash or sulphuric acid; rub the glass well, and after a few minutes the resin, &c., will wash off with water, and the glass may be cleaned in the ordinary way. Wood spirit is a clean solvent of these substances.

(*k*) *Spots of over-development in Photographs.* The solution given above for nitrate of silver stains has been found to answer, but it requires care in using.

(*l*) *Sulphate of Iron Stains, Iron Moulds, and Ink Stains.* To remove these from linen make use of a solution of oxalic acid, and from glass vessels hydrochloric.

(*m*) *Sulphuret of Silver Films in Hypo-bottles.* Remove all that can be rubbed off with tow and water, and then use nitric acid, which will form nitrate of silver: finish with plenty of water.

(*n*) *Turpentine.* Strong alkali and tow will soon soften it, so that it will be moveable by water, or perhaps better, sulphuric acid, which will decompose it.

(*o*) *Varnishes and Varnished Collodion Pictures.* These are all easily removed by wood spirit, even if asphalt or brunswick black has been applied: or, if time be not pressing, let them soak for some days in water, when the varnish will peel off.

Clearness. This quality in a photograph implies the absence of any action except what is induced by the impact of light, the exact amount of exposure, both as to the intensity of the light and the duration of its action, the exclusion of all light except that reflected by the object which is photographed, perfect optical arrangement so that the image is sharp and evenly illuminated, a uniformly sensitive surface to receive the impression, the arrangement of light so that the illuminated object to be taken appears perfectly modelled, and clean, uniform, and smart manipulation. The things to avoid are dirty plates, impure chemicals, too weak or too strong solutions, or those of unknown or inconstant strength, too much heat or cold, bad water, dirty hands or frames, and unclean vessels which cause action independent of the light; lenses with foci not coincident, or with no sharp focus, and of too short focus, and cameras shaky or not light, tight, or not adjusted to the focussing glass, or open in front to rays from any objects beside the one to be photographed, or deficient in means of absorbing the light scattered by the lenses or the mounting, which cause an imperfect image; illuminated smoke or vapours between the object and lens, bright back-ground or sky to the picture, and dew or grease on the lens, which introduce into the camera diffused light that veils the picture; feeble light, or too intense, or not falling upon the object so as to throw out the relief, light coming

too obliquely from parts of the object, and exposure too long or too short, which injure the purity of the modelling; and careless, or unequal, or dilatory manipulation which makes one part of the plate more sensitive or develop more quickly than another.

Cliché. The French word for negative, or mould.

Clips. Little clasps made of wood for hanging up papers to dry. They are best when they are tipped with shellac, or other varnish that the solutions cannot penetrate. A separate set should be kept for each operation. They should be provided with S hooks of wire, so that they may be hung over a line. Such hooks, made with black pins or silver wire, are very useful substitutes for the clips themselves.

Coating Fluid. A solution used in the dry-collodion processes in order to prevent the dry film from splitting, blistering, or wrinkling, on being wetted by the developer. It is composed of two grains of gutta-percha dissolved in an ounce of chloroform. The glass plate is coated with it, and then held for a minute before a red fire before applying the collodion.

Cobalt. A metal resembling, in its photographic applications, iron, nickel, and chromium. It is the basis of smalt, and the blue colour of writing papers. Its compounds with sulphur and arsenic have been found to be affected by light.

Collodio-Albumen Process—Mudd's. Coat the cleaned plate with collodion in the usual way. After allowing the film to "set" well, sensitize in the ordinary nitrate of silver bath. If the collodion should give a very thick and creamy film, it must be reduced by adding ether. After sensitizing, the plate must be well washed, and then placed in a dish containing a weak solution of iodide of potassium and water (about one grain to the ounce of water) for two or three minutes, gently moving the dish the while. Rinse with tap water, and drain a minute.

To the whites of 10 eggs add—

50	grains iodide potassium.
10	,, bromide ,,
100	minims liquid ammonia.
2½	ounces water.

Dissolve the iodide and bromide in the water, then add the ammonia. Mix all together with the albumen, and beat the whole into a froth. Let it settle. It is then fit for use.

While the plate is still wet, pour over its surface the albumen. Pour off again. Repeat this twice. Now allow the plate to drain

five or ten minutes; then dry it rapidly before a clear bright fire, and make it quite hot.

To make the plate sensitive, it is only necessary to dip it for one minute into the aceto-nitrate bath:—

40 grains nitrate of silver.
½ drachm glacial acetic acid.
1 ounce water.

Warm the plate slightly, immerse it, drain a moment, and then wash as before in the dishes, and finally under the tap. The plates may be dried artificially, but will dry without heat in about ten minutes.

Plates so prepared will keep good, in cool weather, six or eight weeks, but in July or August it is better not to trust them longer than a fortnight.

The method of developing at present is with pyrogallic acid. Take the exposed plate, and, after placing it upon the stand, pass over the surface a little common clean water; then take a plain pyro solution without acid, say two or three grains to the ounce of water, and pour it on the plate. This mixture must be made just before use, as it does not keep without acid. The sky and high lights will appear almost immediately, and ultimately, without either silver or acid, the whole picture comes out. It now requires intensity. Now take—

Pyro . . . . . . 2 grains,
Citric acid . . . . . 2 grains,
Silver, two or three drops of 20-grain solution,

and pour on the plate. If necessary, add more silver until sufficient intensity is gained.

A warm solution ought only to be used when the picture is under-exposed. It should always be used in the winter months, when the temperature of the water is low, and in pictures which would not appear with coid water.

Fix in hyposulphite of soda, about six ounces to the pint of water. Cyanide of potassium must not be used for this purpose.

Collodio-Chloride of Silver. This is a sort of emulsion, consisting of collodion holding in suspension for a time chloride of silver. It is used chiefly for the purpose of printing upon opal glass, by contact with the negative. The addition of a small quantity of citric acid to the emulsion is said to impart vigour to the print. The compound is poured over the plate in the same manner as collodion, and allowed to set and get dry thoroughly. It may then be exposed in a suitable printing frame. About double the exposure is required as that for a common silver print. To make the

emulsion, first dissolve the soluble chloride in the collodion, and then add a solution of nitrate of silver dissolved in alcohol. An ounce of collodion will take up about seven grains of nitrate of silver. The chloride of silver only makes an imperfect mixture with the collodion, and does not enter into combination with it, for in whatever manner the emulsion is prepared, it will be found, after a few weeks of repose, that the whole of the chloride is precipitated. This method of printing upon glass is the discovery of Mr. Wharton Simpson, and when properly executed the results are very beautiful.

Collodion. (Gr., *κόλλα*, glue). A term applied to a solution of pyroxyline in a mixture of ether and alcohol.

The manufacture of collodion suitable for the positive and negative process is a matter of some difficulty, and requires considerable experience in the operator before he can always be successful.

The first and most important point is to manufacture a kind of gun cotton called pyroxyline (*see* "Pyroxyline"). The rest of the operation is easy when the alcoholic and ethereal solvents are obtained of the requisite strength and purity.

Formula for Positive Plain Collodion.

Ether, sp. gr. ·725 to ·730	.	12 fluid ounces.
Alcohol, sp. gr. ·810 to ·820	.	4 „
Pyroxyline (*see* "Pyroxyline")	.	110 grains.

In a clean and dry bottle first shake up the pyroxyline with the alcohol, then add the ether, and again shake till the whole of the pyroxyline is dissolved.

Formula for Bromo-iodising the Positive Collodion.

Iodide of ammonium	. .	40 grains.
Iodide of cadmium	. .	40 „
Bromide of ammonium	. .	20 „
Bromide of cadmium	. .	10 „
Alcohol, sp. gr. ·810	. .	4 fluid ounces.

Shake up in a clean bottle with the alcohol till dissolved, and add the whole to the above proportion of plain collodion. Allow to settle for a few days, and decant off the clear portion for use.

Positive iodised collodion should be of a pale sherry colour or a little deeper. Should it not assume this colour after being for a few days iodised, add tincture of iodine drop by drop till the required depth of colour is obtained. Should the solution turn red immediately after the iodiser has been added to it, the inference to be drawn is, that the ether has been kept for some time and become ozonised or acid, from the action of light and air. But this may be no drawback to the successful working of such collodion. Should,

again, the red coloration be absorbed, and the solution become almost colourless, this may be considered a proof that the ether or alcohol contains methyl or wood spirit. In this case it may not be necessary to add tincture of iodine, for the collodion has already shown itself to be slightly acid. The chief object in adding free iodine is to give an acid reaction to the bath.

Formula for Negative Plain Collodion.

Ether, sp. gr. ·725 . .	10 fluid ounces.
Alcohol, sp. gr. ·805 . .	5 „
Pyroxyline (*see* "Pyroxyline") .	120 grains.

Mix in the same way as described above for positive collodion.

Formula 1st. To bromo-iodise the plain negative collodion, take—

Iodide of ammonium . .	40 grains.
Iodide of cadmium . .	40 „
Bromide of ammonium . .	10 „
Bromide of cadmium . .	10 „
Alcohol, sp. gr. ·805 . .	5 fluid ounces.

Shake in a clean bottle till dissolved, and add to the above proportion of plain collodion. After settling, decant off for use.

This iodising solution is specially meant for use with an iron developer.

For a pyrogallic developer the following iodiser is preferable—

Iodide of potassium or cadmium .	50 grains.
Iodide of ammonium . .	50 „
Alcohol, sp. gr. ·810 . .	5 fluid ounces.

In the dry processes a larger proportion of bromide in the collodion than is desirable in the wet should always be employed. Four grains of iodide to two of bromide in each ounce of the collodion is a fair average proportion; but occasionally, especially in the tannin process by alkaline development, the amount of bromide may be considerably increased with advantage, and the iodide correspondingly diminished.

Collodion, whether iodised or plain, should be kept in well-stoppered or corked bottles, nearly full, and as much as possible in a cool and dark place; otherwise it rapidly becomes ozonised, and shows great tendency to decompose some of the iodides, which thus disengage iodine, rendering the collodion slow in action.

Collodion Positive Process. This is a method of taking a direct positive, upon a collodionised surface, without any subsequent printing operation, and by developing the image that is obtained in the camera.

The collodion positive and negative processes differ in the following important particulars; viz.:—

In the negative process the object is to obtain a picture, in which the material of the image shall be more or less *opaque* when looked *through*;—in the positive process, to obtain a picture in which the material of the image shall be a *dead white* when looked *at*. In a negative, density of various gradations is what is required, without any reference to the appearance of the surface deposit. In a positive, *whiteness* of the surface deposit is what is required, without any reference to density. In the negative process, the object is to obtain density in the image by combining organic matter with the reduced silver, so as to obtain sufficient opacity, and not a grey, feeble, metallic image. In the positive process, on the contrary, the object is to *avoid*, as much as possible, the introduction of organic matter in any part of the formula, first by acidifying the nitrate bath with nitric instead of acetic acid, and secondly, by developing with an inorganic developer, such as a mixture of the proto-salts of iron with nitric acid, and in this way endeavouring to produce, not an opaque organic image, brown on the surface, but a thin, white, metallic deposit.

The nitrate bath should be rather stronger in silver than that for negatives, and should be acidified with nitric acid. The formula is as follows:—

Distilled water	1 ounce.
Nitrate of silver	40 grains.
Nitric acid	1 minim.

The time of exposure is about half that required for negatives.

The Developer is made thus:—

Dissolve one ounce of powdered nitrate of baryta in 16 ounces of distilled water, and add 2 drachms of nitric acid, s.g. 1·4. Next add 1½ ounces of powdered proto-sulphate of iron. Shake well until the iron salt is dissolved. The mixture becomes white and turbid, in consequence of the formation of sulphate of baryta. Let it stand a few hours until this has settled to the bottom of the vessel; then decant and filter the solution, which, if right, will be of an apple green colour. Add two ounces of alcohol, to enable it to flow freely over the collodion film. It is now ready for use, but gradually deteriorates by keeping. It may be kept about a month in a cool ce. The nitric acid slowly oxidises the proto-salts of iron and solution turns yellow. In this state it is much slower in its on, and a little fresh proto-sulphate should be added to it. An ce of proto-sulphate of iron decomposes about an ounce of nitrate ›aryta, forming insoluble sulphate of baryta, and soluble proto-

nitrate of iron. The remaining half ounce of undecomposed protosulphate of iron forms the energetic part of the developer.

The nitric acid should be added as stated, and not *after* the iron salt, as some peroxidation of the iron might then occur, which would occasion a browning of the solution, and be injurious.

The mode of developing the picture is quite different from that in the negative process. It must be done almost at a blow, and is completed as soon as there is a visible indication of the details in the shadows when the plate is laid upon a black ground. These details come out very quickly, and the development generally occupies only a few seconds. If it be carried too far, the boldness and vigour of the contrasts are destroyed. Over-exposure produces a blue solarized appearance, as in the daguerreotype process.

The picture is to be washed, and fixed with cyanide of potassium; then washed again, dried and varnished in the same way as a negative; after which, the back of the plate is to be coated with black varnish. Some operators varnish the picture itself with black varnish, because then it is non-reversed on looking at it through the glass; but this is a bad plan, because the varnish injures the tone of the whites, and is very liable to crack and destroy the picture. When applied to the back of the plate, it can easily be rubbed off and renewed if it cracks, and no harm is done to the picture. *See* "Varnish."

Positives should be taken in a non-reversing slide whenever the reversion of the image is objectionable.

Some operators take positives upon purple glass, which forms an excellent background to the picture, and renders the use of black varnish unnecessary. This is an excellent plan.

Positives may be taken upon a variety of substances, such as black-varnished paper and card, black-enamelled iron tablets, black patent leather, black-glazed canvas, &c., &c. Some of these processes are very ingenious and useful, and deserve a particular description.

To take Positives upon Paper, or Card. The paper or card must first be gelatinized by floating the side on which the picture is to be taken on a warm strong solution of gelatine, and drying it. It is then cut a little smaller every way than a glass plate, to which it is to be attached in the following manner:—Lay the back of the paper upon the glass, heat the blade of a penknife in a spirit lamp, rub it upon a lump of wax, and then pass it quickly all round the edge of the paper so as to fasten it to the glass plate by an edging of wax, without allowing any liquid to get behind it. Next coat the paper with black varnish, and let it dry. Then take the positive in the ordinary way, and when finished cut off the edges of the paper and detach it from the glass. Positives taken on paper or card in this

way may be safely transmitted by post. The object of the gelatine is to prevent the black varnish from soaking into the paper.

To take Positives on Patent Leather, Glazed Canvas, Enamelled Iron Tablets, &c. The leather or canvas is to be attached to the glass by an edging of wax, in the manner described for paper, and the positive taken on the glazed surface at once, without black-varnishing it. Enamelled iron tablets may be treated in precisely the same way as a plate of purple glass. The back of the tablet should be varnished so as to prevent its injuring the nitrate bath.

Collodion positives may be transferred to a great variety of tablets.

Collodion Processes (Negative). The collodion negative process with a pyrogallic acid developer is now rarely practised; but it is deemed advisable to give a succinct summary of it in this Dictionary. A proto-sulphate of iron developer is that which is generally used.

1st. *Negative Process with Pyrogallic Acid Developer.* Select a collodion iodised by the second formula; *see* "Collodion." A bromo-iodized collodion will answer, but it is not nearly so sensitive. It may, however, be occasionally found preferable under circumstances of high temperature, and when the light is very actinic.

Formula for nitrate bath.

Recrystallized and neutral nitrate of silver .	300 grains.
Distilled water	10 fluid ounces.
Glacial acetic acid	1 drop.

Dissolve and filter. Pour into the glass trough, then coat a clean glass plate (say 5 × 4 inches for the above proportion of solution) with collodion, and allow all the iodide of silver, which at first is formed in the film, to be dissolved out by the nitrate of silver. It may occupy more than a quarter of an hour before the glass resumes its original transparency. The bath is now said to be iodized—that is, its tendency to dissolve iodide of silver is considerably diminished —and it is ready for use.

To coat the Plate with iodized Collodion. The plate must first be cleaned in the manner described in the article "Cleaning," and then well polished with a cambric rag, or leather buff, immediately before pouring on the collodion; for, unless the plate is wiped thoroughly dry and well polished before use, it will be covered with streaks or marks where the damp rag last touched it. The breath condenses upon a clean, dry, polished plate in an even sheet, without exhibiting marks or irregularities.

Hold the plate horizontally, by one corner, between the finger and thumb of the left hand, if a small plate, or place it on a plate holder

(*see* "Plate Holder"), if too large to be conveniently held in this way, and pour upon the middle of it rather more collodion than is sufficient to cover it with a good thick layer. Then tilt the plate so as to let the collodion flow towards the thumb, but without touching it, and afterwards to the other corners in succession, and pour off the surplus into the bottle from the corner opposite to that by which you hold it. This done, keeping the corner of the plate still resting upon the neck of the bottle, and holding it vertically, rock it three or four times quickly through a wide angle, in order to prevent the formation of lines in the collodion; then place it upon the dipper ready to be plunged into the nitrate bath.

Be careful to wipe the neck of the collodion bottle occasionally, as bits of dry collodion which are formed there are liable to become detached and deposited on the plate; also, avoid dust in the dark room, and blow off, or better, brush off with a camel's-hair brush any floating particles which settle upon the plate, before coating it.

To excite the Film. The ether evaporates very quickly from a coated plate, and the fluid collodion speedily gelatinizes. This is called "setting." When the collodion has sufficiently set—that is, as soon as it ceases dropping from the corner of the plate—and is safely placed upon the dipper, immerse it, without pausing, in the nitrate bath; a pause during the immersion producing a line across the plate. Then move it from side to side in the bath, for a few seconds, in order to prevent the formation of streaks in the direction of the dip, and leave it immersed for a couple of minutes or so. Then raise it out of and lower it into the bath gently two or three times, in order to wash off the ether and get rid of the greasy, streaky appearance of the film; let it drain for a few seconds over the bath; wipe the back of the plate with blotting-paper, and place it in the slide, taking care never to invert the slide while the plate is in it, which would allow the free nitrate which drains towards the bottom to flow back over the partially dry upper surface of the plate. Immediately expose in the camera for what may be considered the requisite time. The effects of over and under exposure can only be seen during development; but experience is the best preliminary guide.

To develop the Image. Pour over the plate a solution containing:—

Distilled water	1 ounce,
Pyrogallic acid	1 grain,
Glacial acetic acid	20 minims;

or

Distilled water	2 ounces,
Pyrogallic acid	2 grains,
Citric acid	3 grains.

It is convenient to make a small quantity of developer of three times the above strength, and to dilute it when wanted. You have, then, at hand a little strong solution to use, should occasion require. The developer will not keep longer than three or four weeks. A little alcohol added to it makes it flow more freely over the plate. It should be filtered if any floating particles appear in it. Citric acid is much cheaper to employ than acetic acid, and it answers very well, giving negatives of a more inky tint than acetic acid; but it must be carefully weighed, as a grain or two more or less may make a considerable difference, citric being a very powerful retardent in the developer.

Fix the negative, when fully developed, with a saturated solution of hyposulphite of soda, not with cyanide of potassium, which will dissolve out all the unimpressed iodide of silver. Afterwards wash the plate in a stream of running water for three or four minutes, to remove the excess of hyposulphite or cyanide, which, otherwise, would gradually destroy the image.

2nd. *Negative Process with Proto-sulphate of Iron Developer.* In this case the plain collodion should be bromo-iodised by the 2nd formula (*see* "Collodion"), and the nitrate bath prepared in a slightly different manner. Mix and iodize the bath as before, but, instead of one drop of acetic acid, add to it one drop of nitric acid for each 10 ounces of solution. The plate is to be cleaned, coated with collodion, sensitized, and exposed also in the same manner, the only difference of treatment being in the mode of development, which is as follows:—

Developing solution.

Proto-sulphate of iron . . .	15 grains.
Water (common)	1 fluid ounce.
Glacial acetic acid . . .	20 minims.
Alcohol (not always required) . .	20 minims.

The method of applying this solution to the exposed film is of great consequence. The plate should be held in the left hand, nearly level, and the developer flushed over it as speedily and evenly as possible; at the same time care must be taken to prevent it from flowing over the edges of the plate. When a sufficiency has been poured on, rock the plate gently with a circular sort of motion, till the image has been developed to the desired degree, or till symptoms of fogging begin to manifest themselves.

It very seldom happens that a negative with sufficient printing intensity can be developed by the first application of the iron. This desirable consummation only occurs when the collodion itself contains organic matter, which combines with nitrate of silver, or when

the developer contains a similar substance (*see* "Ferro-gelatine Developer").

To intensify the feeble negative produced by the plain acidulated iron developer, there are two ways of working. Having washed off the first solution, the instant that it has done its work, take a fresh portion of the acidulated iron solution in a clean developing glass, add to it a few drops of nitrate of silver solution, and with this recommence the development. If this do not bring out sufficient intensity, repeat the dose again, and again if necessary, taking care to wash the film with water between each repetition. Mr. Wilson, one of the most eminent of our landscape photographers, adopts this method, with extraordinary success.

The second mode of intensifying an iron-developed picture, and the one generally employed, consists in reinforcing the feeble negative with pyrogallic acid and silver. Make solutions:—

1.	Pyrogallic acid	1 grain.
	Distilled water	1 fluid ounce.
	Citric acid	1 grain.
2.	Nitrate of silver	20 grains.
	Distilled water	1 fluid ounce.
	Glacial acetic acid	1 drachm.

Wash the iron-developed plate under the tap for about a minute or two, to get rid of all the iron, which otherwise would, with the pyrogallic acid, form *ink* and retard the action. Then pour out into a clean beaker sufficient of solution No. 1 to cover the plate; add to it a few drops of No. 2, and with this continue the development to any desired intensity.

Fix with saturated solution of hyposulphite of soda, in preference to a weak solution of cyanide of potassium, which some recommend. Wash thoroughly and dry.

Should the image, after fixing and washing, be deemed not dense enough for printing purposes, it can, in this stage, be still further intensified by either of the above methods; but, to do so effectually, it is absolutely necessary that the last trace of the fixing agent, whichever it may be, shall be washed away from the film. A re-intensification, after fixing, requires only a subsequent washing of the film in plain water to render the image permanent.

Of course it is presumed the reader understands that the sensitizing and developing of collodionized plates must be done in what is called the "dark room." The fixing may be done in white light with impunity, provided the developing solution has been removed from the surface of the film.

Collodion negatives, *when dried*, are not permanent unless they are

varnished. The pyroxyline film is gradually decomposed by contact with air and moisture, and an oxide of nitrogen produced, which destroys the photograph. Indeed, without varnishing, the film is so easily scratched that it is almost impossible to print from them without injury. When properly varnished, however, they appear to be extremely permanent, and also stand a great deal of rough usage. Good spirit varnish is the best, and amber varnish one of the worst to employ (*see* "Varnish"). When spirit varnish is used, the plate should be warmed before the fire, both before and after the application, but not made too hot, or the negative might be dissolved off the plate. The varnish is poured on in the same way as the collodion. It dries very quickly. Other varnishes are applied in the same way to a cold plate, which should, however, be thoroughly dry.

The negative is now finished.

General Remarks. When the collodion refuses to flow over the glass plate evenly, and sets in irregular ridges, this indicates one of two defects in its preparation, or both. Pyroxyline prepared at a too low temperature, and the solvents of it containing more water than indicated in the formulæ under the head "Collodion," produce the defect alluded to; but when both these sources of failure are combined, the collodion is worthless, and should be rejected.

It is of considerable importance not to allow the plate to remain in the sensitizing bath longer than necessary. As soon as the greasy lines previously referred to in this article have disappeared, the film is in the best condition for yielding a good negative. A longer immersion tends to fogging of the image under the developer, for the reason that it is necessary for a clear picture that some of the soluble iodide or bromide in the film should remain unconverted into the sensitive salt. If, therefore, the plate remains in the nitrate bath long enough to convert the whole of the underlying soluble haloids in the film, fogging more or less is sure to ensue.

In judging of the proper time of exposure from observing the effects of the developer on a trial plate, a considerable amount of practical experience is required to determine whether the bad effects which arise may not be due to the chemicals rather than to the time of exposure. An excellent method for determining this point is the following:—Expose in a twin-lensed camera a stereoscopic plate, giving one half of the plate an extremely short exposure, and the other half a prolonged one. Develope both together. If both sides fog, or yield no picture, then the chemicals are in fault, but

if the one which had the least exposure shows an image or traces of an image free from fogging, and the other a negative without contrasts, then the chemicals are in good condition, and the proper time of exposure may easily be calculated.

Spots and stains on negatives arise from so many sources that they cannot be categorically described in the space at our disposal. The great safeguard against most of them consists in absolute cleanliness, in purity of chemicals, and in bending one's whole attention to each stage of the process while it is in hand. Glass plates which have been previously used are often a source of great annoyance, because persistent stains, from some cause or other, will continue to occur in the same place, cleanse the plates how we will. Such plates should be destroyed.

Collodion, Bromised. Major Russell has discovered that a simply bromised collodion is exquisitely sensitive in the dry tannin process, when the alkaline developer is used. He recommends the collodion to be made as follows:—

Pyroxyline	5 grains.
Bromide of cadmium . . .	8 grains.
Alcohol, sp. gr. 805 . . .	4 drachms.
Ether, sp gr. 725	4 drachms.

For the method of using it *see* "Tannin Process."

Collodionized Paper. Paper, either plain or coloured, if coated with collodion, can be painted upon, in oil colours, as well as if prepared in the usually costly manner. Photographic prints upon paper can, by being coated with collodion, be painted in oil colour.

Colour. If the coloured spectrum produced by passing a ray of sunshine through a prism, and thereby decomposing it into coloured rays of different refrangibilities, be thrown upon a sheet of sensitive photographic paper, the paper is most darkened by the violet rays, and least by the yellow and red. This shows that the chemical power of light resides chiefly in the violet rays. Now the colour of an object when illuminated by white light is supposed to depend upon its absorbing all the coloured rays which fall upon it, and, when combined, produce white light, *except* the rays of the particular colour which it emits: so that, on this hypothesis, it might be supposed that the images of yellow and orange coloured objects would scarcely produce an impression upon a photographic tablet, while those of objects of a blue or deep violet colour would produce a comparatively marked effect. This is found by experiments to be true to *some* extent in the case of coloured objects

copied in the ordinary way, and to a *greater* extent in the case of light transmitted through coloured media. For instance, if a painting in fresco were exposed to full sunshine, and copied in the ordinary way, the photograph would not be so perfectly truthful in its mode of rendering shade for colour as an engraving from the same picture, because the yellows and reds would be darker, and the blues and violets lighter, in the photograph than in the engraving, in which light colours would be properly represented by lights, and dark colours by shades. But, if the same fresco were faithfully copied by a transparent painting upon glass, and this copy were photographed by superposition upon a sensitive tablet, and a positive printed from a negative so obtained, the untruthfulness of this positive, as regards light and shade, would be much more marked than in the former case. It appears, therefore, that a coloured object emits from its surface certain actinic rays besides the rays of its peculiar local colour, and that the photographic copy of a coloured object obtained in the ordinary way is not *quite* so inaccurate in its mode of rendering colours by shades as might at first be supposed.

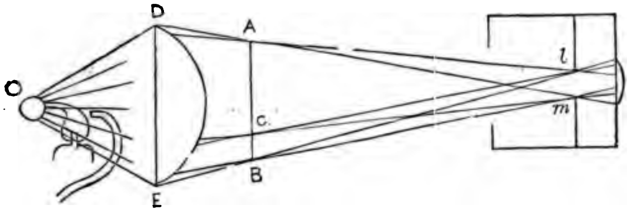
As a rule, the photographer should remember that *blues* and *violets* come out *lighter*, and *yellows* and *reds darker*, in a direct or printed positive, than they ought to be.

It seems probable that different coloured artificial lights, or sunshine transmitted through coloured media, might be successfully employed in illuminating coloured objects to be copied by Photography. A variety of highly-interesting experiments might be made in this direction, with the view of removing, if possible, from Photography the reproach under which it somewhat justly labours. As yet, very little has been done in the way of careful scientific experiments in the photography of coloured objects, and our information is consequently scanty on this head. The difficulty found in copying old oil paintings arises in a great measure from their exceedingly dingy and low tone of colour, which will be perceived by holding a white card against the highest lights; and also from the varnished and uneven surface, texture of the canvas, and other defects.

Yellow paper, calico, or glass, used for cutting off actinic light, should have a tinge of orange, rather than green, as the red are much less actinic than the blue rays.

Condenser. A thick convex lens, or pair of such lenses in contact, used for the purpose of directing rays of light through any transparent object intended to be copied, in the manner described

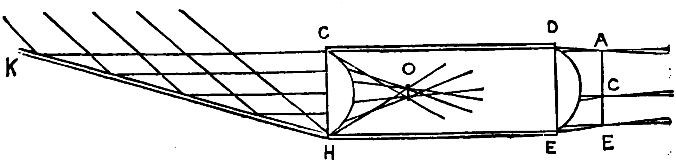
in the article on copying. Its use and mode of action will be understood from the following diagram.



A B is a transparent object to be copied, *l m* the diaphragm of a copying lens (or doublet, suppose), O an artificial light (the oxy-calcium light, for instance), D E the condenser.

The condenser is larger than the object to be copied; its principal focal length should be a little shorter than its distance from the incandescent lime ball O; and the image of O should be formed indistinctly in the neighbourhood of *l m*. All the rays included within the angle D O E will then be transmitted through A B and the copying lens, and the images of the transparent parts of A B will be formed by diverging pencils, as shown at the points A, C, B, and in the manner described in the article on copying. (*See* "Copying.") The condenser may be plano-convex, with the *plane* side next to the light; or a compound, as shown in the article on the magic lantern. It is evident that if the lens D E had *no* spherical aberration, the pencils *l* A *m*, *l* C *m*, *l* B *m*, would become straight lines, and the condenser would be useless.

When sunshine is to be used instead of artificial light, the form of the condenser may be modified, so as to suit the parallel rays incident upon it, as shown in the Figure.



G H E D is a cylindrical tube, having at each end a plano-convex lens. H K is a reflector, by means of which the sun's rays are directed into the tube. The first convex lens gives a confused image of the sun at its principal focus O, and rays then diverge

from O, and pass through the second lens in the same way as from the lime ball in the figure.

It will be seen that, without the condenser D E, very little of the light that is radiated from O would pass through the negative and enter the camera through the stop of the copying lens. The condenser collects diverging rays, and causes them to converge to the points desired.

A condenser is never achromatized. A very little consideration will show the absurdity of doing such a thing. It matters not how heterogeneous the light may be when it falls upon the achromatic copying lens, because it is the business of *that* lens to destroy the chromatic aberration of the pencils.

Conjugate Foci. It is an admitted principle in geometrical optics, that when a ray of light has passed through any optical instrument composed of lenses and reflectors, it will, on having its direction reversed, return by the same path as that which it previously followed. If, therefore, a pencil of rays diverging from a luminous point Q be refracted through a convex lens, or convex system of lenses, and brought to a focus q, it follows that, on reversing the direction of every ray, and considering q as the origin of a pencil proceeding the contrary way to the first, every ray will return by its former course to Q, the origin of the original pencil, which may therefore be considered as the focus corresponding to the origin q. From this circumstance the points Q and q are called "Conjugate Foci."

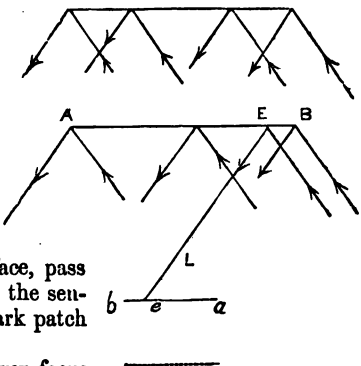
Copying. This term is used in Photography when manuscripts, maps, paintings, engravings, and works of art of that class are to be reproduced.

In copying black marks upon a white ground by the collodion process, it is generally advisable to have recourse to organic matter in the collodion, in order to obtain density at the expense of sensitiveness and half tone. An old and rather discoloured collodion should therefore be used, and the nitrate bath may be more strongly acidified than usual. The work to be copied should then be placed either in a strong diffused light or in sunshine, and a small stop used to the lens. Care must be taken not to give so much exposure as to redden and enfeeble the blacks of the negative.

The development may be effected either with protosulphate of iron, and the image intensified with pyrogallic acid and nitrate of silver as usual, or it may at once be developed with pyrogallic acid to the requisite printing density.

The copying of oil paintings is a matter of some difficulty, be-

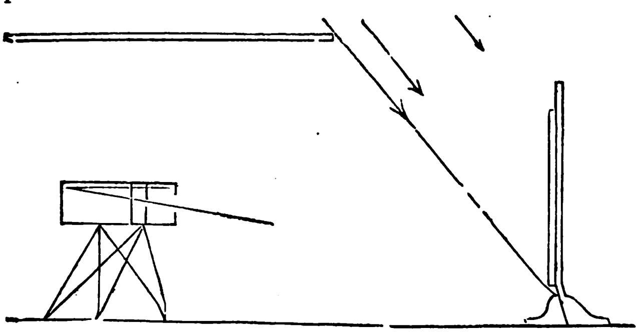
cause reflected light from the varnish is likely to enter the camera and blacken some part of the negative. A lens of long focus should be employed, for reasons which will be understood by reference to the following diagram, which is exaggerated in its proportions, in order to render it more intelligible.



Let A B be a varnished oil painting, L the lens, and *a b* the image; the lens being one of short focus and placed near to the painting. Suppose the painting illuminated by light falling obliquely upon it, as shown by the arrows. Then some of the rays incident about E will, after reflexion at the varnished surface, pass through the lens, and fall upon the sensitive plate at *e*, producing a dark patch in the negative.

Next, suppose a lens of longer focus used, and the picture placed further from it, the image being the same size as before, as shown by the dotted lines; then no reflected rays will fall upon the sensitive plate, but they will all pass to the left of the lens.

In copying oil paintings, it is important, therefore, to use a lens of long focus, so as to avoid introducing very oblique pencils. The following is another point of equal importance. If light objects are immediately behind the camera, the light from them will strike the painting nearly at right angles, and then be reflected into the camera. This will be avoided by the arrangement shown in the figure, which explains itself.



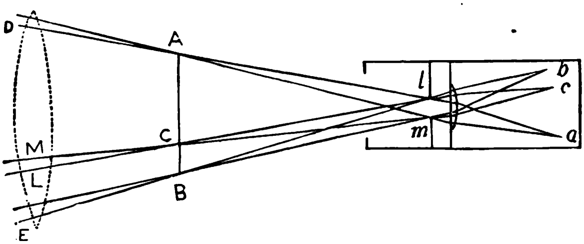
Daguerreotypes may be copied in full sunshine, the original being placed at the end of the projecting front of an appropriate camera, and the light thrown obliquely upon it through an open lid in the top of the box, the inside of the box being blackened, or lined with black velvet.

Water-colour drawings, oil paintings, and all objects having a rough surface, should be copied in a strong diffused light, and *not* in sunshine, because that would cause a shadow to be thrown by every inequality of the surface.

It now remains to add a few words on the mode of copying transparent negatives by means of a copying camera.

A good deal has been said on this head in the article on the copying camera (*see* "Copying Camera"), and it only remains to discuss the various methods of obtaining a luminous background to the transparent negative. As this is a point which should be thoroughly understood, we shall endeavour to make it as clear as possible with the aid of a diagram.

The great principle to be borne in mind in the optics of Photography is, that the object to be copied is an assemblage of bright points, each of which is the *origin of a pencil* of rays, and that the image formed by the lens is an assemblage of *foci* of these pencils. From every point of the object a diverging *pencil* of rays proceeds, which after refraction through the lens is brought to a focus on the focussing screen. Now, in copying a transparent negative, the case is evidently different from that of copying an engraving or print placed in the same position with respect to the lens. For instance (see figure), if A B is an engraving and C any white point of it,



a pencil of light diverging from C is refracted though the lens, and brought to a focus at *c*;—but if A B is a transparent negative ıd C a piece of transparent glass, it is evident that C cannot be ɜ origin of a diverging pencil of light in the same way as before, less rays transmitted through C from a luminous background

behind can be made to intersect at C, and then pass on as if C had been an origin of light.

This being understood, let us suppose that the dotted line D E behind A B is either the sky or an illuminated white screen. Then, if C be considered a minute transparent hole, the sky or screen could be seen through it by an eye placed anywhere between l and m, and, therefore, rays M C m, L C l, would intersect at C, and produce the effect of a pencil diverging from C. And similarly of every other transparent point of the negative. It appears, therefore, that when a transparent negative is copied with the sky or an illuminated screen as a background, the same effect is produced as if the transparent parts of it were opaque but luminous, and emitted diverging pencils of light.

In all cases, the diameter of the stop, or lens, is small compared with the distance of the lens from the negative; therefore the angles l A m, l C m, l B m, are small; and if, instead of the sky or an illuminated screen, D E were a convex lens transmitting a pencil of light D A E B, which converges with great spherical aberration towards a focus in the neighbourhood of l m, the same effect would be produced as before. A lens of this kind is called a "Condenser" (*see* "Condenser"), and transparent negatives may be copied by means of it, with either an artificial light placed behind it, or reflected sunshine transmitted through it.

When any object is to be copied by superposition in the pressure frame, the ordinary printing processes may be employed.

Copperas. A term sometimes used to denote protosulphate of iron, *q. v.*

Corrosive Sublimate. Another name for chloride of mercury, *q. v.*

Corundum. Is the Indian name for a mineral called also Adamantine Spar. Its extreme hardness renders it useful to lapidaries and seal-cutters, and to photographers, for grinding the edges of their glass plates. Small corundum files for the latter purpose may be purchased at most of the photographic warehouses.

Cosmorama Stereoscope. A stereoscope in which the lenses through which the picture is viewed are made nearly as large as the picture itself, and a segment of each cut off, in order that they may be brought with their centres not more than about three inches apart. This form of stereoscope has some important advantages, and its only drawbacks are the increased weight and cost.

Cotton. Formula, $C_{36} H_{30} O_{30} = 486$. This substance con-

sists of almost pure cellulose. The kinds of cotton met with in the market are generally designated by the names of the places from which they are brought, but the only kinds suitable for making a good pyroxyline are the *long-stapled* varieties, the best being Sea Island, and next to it the long-fibred Egyptian.

Cotton as imported is not suited for the manufacture of pyroxyline. It must be thoroughly combed and cleansed from all impurities. This is partially done before the cotton reaches the retail market; there still, however, remains an impurity in the cotton which should be got rid of before it is capable of producing the most soluble kind of pyroxyline. The impurity is a coating of resinous or oily matter adhering to the fibre, and is derived from the seed-pod from which the cotton was taken. It is, therefore, advisable, although not absolutely necessary, to saponify the oily matter, by boiling the cotton for some time in a *very weak* solution of potash, then washing in abundance of common water, and thoroughly drying it before immersion in the mixed acids.

Cribriform. (Latin, *cribs*, a gridiron.) When a paper negative is viewed by transmitted light, it sometimes appears covered with intersecting diagonal lines, like network. This appearance is called "cribriform." It is produced by the wire frame in which the paper is made. Sometimes an insoluble precipitate is formed by the developer in the pores of the paper, and then the cribriform appearance is more marked. Immersion in a bath of dilute muriatic acid will sometimes remove this precipitate, and then by a long immersion in almond oil the paper may be rendered evenly transparent.

Crossed Lens. This is the form of single convex lens which has the least spherical aberration. If the refractive index of the glass be 1·5, the radius of the posterior surface should be six times that of the anterior surface, both surfaces being convex.

Crystal Cubes, Swan's. This ingenious application of the angle of total reflection of glass surfaces to stereoscopic purposes was devised and patented by Mr. Swan, of London. The small photographs are taken in the usual way in a stereoscopic camera, and the combination of the two flat pictures, so as to produce the true stereoscopic effect, is managed by taking two rectangular prisms of glass ground to an angle of about 39° or 40°. These two prisms are placed together with their widest sides in contact, or nearly so. One of the pictures is then attached to one side of the combination, and the other behind. On looking at them, the rays which reach one of the eyes are transmitted direct from the picture on the back

of the glass; but the rays which reach the other eye are not from the back, but from the side only, being reflected from the surfaces of the prisms where they touch. Thus it appears to be from the back also, and is made to coalesce with the other, so as to give astonishing stereoscopic relief.

Curvature of the Image. This is a term used in Optics to denote the fact of an image not lying upon a plane, but upon a spherical or other curved surface.

The "real image," formed by a convex lens, is an assemblage of the foci of pencils which proceed from the various points of the object. The situation of these foci, whether on a plane or curved surface, is independent of the amount of spherical aberration which may exist in each or any of the refracted pencils. "Curvature of the image" is therefore a totally different thing from "spherical aberration," and the terms must not be confounded.

There may be considerable curvature of the image when there is no spherical aberration, and *vice versâ.*

As photographs are generally taken upon a flat and not a curved surface, curvature of the image is a very serious evil in a photographic lens. The mode of remedying it, by increasing the radius of the field of these instruments, is fully described in the article "Lens."

Cyanides. Compounds of cyanogen formed on the hydrogen type. Although cyanogen itself is a compound of carbon and nitrogen, it acts exactly like an element. The only cyanides used in Photography are those of potassium and silver, *q.v.*

Cyanotype Processes. These are certain processes, discovered by Sir John Herschel, in which cyanogen is employed.

1st Process. A piece of paper is first washed with a solution of ferrid-cyanide of potassium (red prussiate of potash), and dried. In this state it is of a yellowish colour, and highly sensitive to light. By sufficient exposure, either in the camera or pressure frame under a negative, the salt becomes converted into prussian blue in those parts where light has acted. To fix the picture, the paper must first be soaked in water, then in a weak solution of carbonate of soda, and dried.

Before washing, the shadows of the photograph are of a lavender tint on a yellow ground, but, after washing, of a deep blue tint on a white ground. Prussian blue is not a permanent substance; perhaps immersing the papers in tannic acid might blacken the colour and increase the permanence of the precipitate.

The action of light in this process is probably to convert the

ferrid-cyanide of potassium into the ferro-cyanide of potassium (yellow prussiate of potash) and form prussian blue.

2nd Process. A sheet of paper is first washed with ammonio-citrate of iron, and dried. It is then of a yellowish colour, and sensitive to light. After sufficient exposure in the camera, or pressure frame, *i.e.*, until an image is faintly perceptible, the paper is brushed over with a solution of ferro-cyanide of potassium (yellow prussiate of potash). This brings out the picture of a deep blue tint, which becomes almost black if the paper is allowed to get dry.

The photograph, in this state, is not permanent. It darkens all over *in the dark* by exposure to air. If washed with ammonia, or carbonate of ammonia, it is for a few moments obliterated, but soon reappears with *reversed lights and shades.* In this state it is fixed, and after being thoroughly washed in water, the shadows are pure prussian blue, which deepens by keeping. By this process negatives may be multiplied; but it is so uncertain in its results as to be of little or no practical value, at present.

The rationale of the process appears to be that the ammonio-citrate of iron, which is a persalt of iron, is reduced by light to a salt of the protoxide. This reacts on the ferro-cyanic salt, and produces the blue precipitate.

3rd Process. Brush over a sheet of paper a mixed solution of ammonio-citrate of iron and ferrid-cyanide of potassium, containing about equal proportions of these salts. Dry it in the dark. It is sensitive to light. After exposure, immerse it in water and dry it, when a blue picture will be produced. If this be immersed in a weak solution of proto-nitrate of mercury, it is quickly bleached and destroyed. The mercury salt being then thoroughly washed out of the paper, the picture may be reproduced by ironing it with a very hot iron. The colour is then brown, which fades gradually in the dark, but may be restored at any time by ironing the paper as before.

These cyanotype processes may be greatly varied by substituting for the ferro and ferrid-cyanide of potassium the corresponding cyanogen compounds of many other metals. A wide field is open for experiments in this direction.

Dado. In architecture means that part of a pedestal which lies in the middle between the base and the cornice, but in Photography the term has been applied to many objectionable upholstering appliances in the glass room.

Daguerreotype Process. By this process a direct positive

is obtained upon a silvered metal plate. It was first published by M. Daguerre, in Paris, in January, 1839.

The picture is produced by means of the fumes of iodine, bromine, and mercury, acting on a silvered plate which has been polished to the utmost. The photo-chemical reactions consequently occur in an inappreciably small quantity of material, which is spread on the photographic tablet with a uniformity not to be obtained by any other means. Hence it follows that a fine daguerreotype exhibits microscopic perfection of detail, and perfect gradation of shades. Other processes, when compared with this, are coarse and imperfect in the results, and of all known methods of representing a natural object by Photography, the daguerreotype process is the most perfect and scientific.

In a fine daguerreotype, the utmost delicacy of line is combined with perfect gradation of shade; the details of the deepest shadows are as legible as those in full light; and the most elaborate finish is blended with exquisite softness of effect. In tone, nothing can be more beautiful than the varied hues of gold and purple which the image presents when viewed in different positions in a strong light.

Unfortunately, however, the very circumstance which gives such perfection to the result, viz., the polish of the plate, brings with it certain objections in an artistic point of view; and these objections are considered by many to be so serious that they are willing to rest content with an inferior photograph upon a different tablet. Hence the present popularity of the glass and paper processes. But the accomplished photographer, who sees in every process its own peculiar merits, will hardly rest satisfied with a coarse production, however artistic, when called on to exhibit the utmost perfection of his art. We would therefore earnestly call the attention of the reader to this elegant and beautiful process, at present so undeservedly cast into the shade by others of less merit.

The manipulation of the daguerreotype process is extremely easy and certain. It involves the following five operations, viz.:—

1st.—To clean and polish the plate.
2nd.—To render it sensitive.
3rd.—To expose it in the camera.
4th.—To develop the image.
5th.—To fix the image.

The finished picture is placed in a frame or passe-partout, behind a glass. The image is permanent, and cannot be rubbed out by the finger; nothing but a chemical solvent will obliterate it.

The silvered plates generally employed in this process are manufactured in France, England, and America. The English plates

are the best—but they are dear. The amateur had better make his first experiments on the American plates of Scovill and Co., or on the cheaper kinds of French plates, of which there are many varieties. He must choose them as free from scratches and specks as possible, as these defects cannot be remedied. The plates are made by laying a thin sheet of silver foil upon a copper plate, and then passing it between rollers, by which means the two metals are made to adhere perfectly. The silver should contain no alloy. When the same plate has been used several times, the silver wears off, and the plate should then be re-silvered by the electrotype process; but all scratches and specks are faithfully copied, so that this process does not afford a remedy for these defects. A scratched plate is useless, except for experiments. The plates may be cut to any shape by a strong pair of scissors.

In what follows, the plate is assumed to be the quarter size.

1*st Operation.—To Clean and Polish the Plate.*—If necessary, cut a little bit off each corner, and bend the edges in a plate bender.

To clean the plate, procure some Canton flannel, and a box of prepared rotten stone with a muslin strainer. In a pint bottle mix one part nitric acid and twenty parts distilled water.

If the plate has been used before, and has been submitted to the gilding solution, the image must be removed by a liquid sold under the name of "Gilding Dissolvent," the directions for using which will be found on the label of the bottle.

If the plate has by accident been in contact with mercury, it must be heated over a spirit lamp until the whole of the mercury has been volatilized and expelled.

Then proceed to clean it in the following manner:—

Cut the Canton flannel into pieces about two inches square. Lay one of them on the plate, and pour on the back of it a few drops of dilute nitric acid; rub the damped flannel all over the plate, going well up to the corners. Then powder a little rotten stone on the plate, and rub it all over with a bit of flannel, with a circular motion, until it is *clean.* Beware of scratching the plate. By scratches are not meant the fine circular marks left by the rotten stone, and which are removed on the buff, but the deep cuts made by a crystal of sand or dust on the flannel. When the plate is clean, it presents the grey appearance of unpolished silver, and is free from stains or marks. When you have cleaned the face of the ate, clean the back with the same piece of flannel, and then with a esh piece of flannel rub the face again until it is dry. The clean ate must not be touched by the fingers.

nolish the plate, procure some prepared charcoal and a couple

of buffs. Tie up about an ounce of the charcoal in a piece of cambric, and keep it in a box with a lid, in order that no dust may stick to it. The buffs are made in the following manner. Procure two pieces of wood 16 inches long, 6 inches wide, and 1 inch thick. Screw a strong handle on the back, at the end of each. Cover one with fine velveteen, and the other with cotton velvet. The cord of the velveteen is to be put *across* the buff. When not in use keep them face to face.

Powder some charcoal all over each buff with the dabber, and rub them together. Then, taking the velveteen buff in the left hand, and resting the end of it on a table, lay the clean plate face downwards on it, and with the fingers of the right hand on the back of the plate, rub it up and down the buff vigorously, in every direction, sideways, longways, diagonally, until you have polished it, and removed the circular marks of the rotten stone. Change continually the position of your fingers on the back of the plate, and in order to prevent them from slipping off on to the buff, breathe on them occasionally, or wear a leather glove. If they slip on to the buff, immediately powder some charcoal upon the spot.

When the plate is thoroughly polished it looks black, and not grey. Polish well up to all the corners and edges, and then put it away into the plate box. Clean and polish enough plates for the day's use, before proceeding to manipulate. A plate may be cleaned and polished in two or three minutes in the manner described, but it is hard work, and may be handed over to an intelligent assistant. The remaining processes are extremely neat and elegant; much more so than the collodion or paper manipulation.

2nd Operation.—To render the Plate Sensitive.—Powder some charcoal upon the velvet buff, and rub the polished plate lightly up and down for half a minute. The fine lines left by the buff across the plate must be horizontal, when you are looking at the picture; remember this when giving the last rub to the plate.

The plate is now ready to receive the sensitive coating.

Procure a double coating box, containing two compartments, one for iodine, the other for bromide of lime, and furnished with reflectors. See that the sliders fit air-tight over the glass pans. Put an ounce of iodine into one pan, and four ounces of bromide of lime into the other. Spread them evenly over the bottom, and lay some cotton wool thinly divided over the iodine, in order that the fumes may be filtered, as it were, and rise more equally.

Place the coating box between yourself and a small window, shaded by a white blind, and open the back shutters of the coating box so that a feeble white light may enter, and be reflected from the mirrors.

Place the plate face downwards over the iodine, draw out the glass slider, and observe by means of the mirrors the changes of colour which the plate assumes. These occur in the following order; viz., pale yellow, deep yellow, rose colour, steel colour, the original colour of the plate; after which the colours recur in the same order as before.

Leave the plate over the iodine until it assumes the deep yellow colour bordering on rose. This may occupy from one to three minutes, according to circumstances. Then pass it on to the bromine. Leave it over the bromine until it assumes a blue steel colour. This may occupy from twenty seconds to two minutes, according to circumstances. Then shut the back shutters of the coating box, and draw a yellow blind, formed of three layers of yellow calico, before the window. Return the plate to the iodine, and let it remain from ten to twenty-five seconds, according to circumstances.

The white light which falls on the plate while you are observing the colour produces an effect, for the plate is certainly sensitive at that time; but the second exposure to iodine obliterates that effect, and renders it harmless. If, therefore, any accident occurs in taking a picture, even should it be exposed to broad daylight in its sensitive state, the effect of the light may be obliterated by exposing it once more for a few seconds to iodine. The plate need not be cleaned, polished, and sensitized again.

The plate is now ready for the camera, and the sooner the picture is taken the better. It may, however, be kept in a sensitive state for some hours, when proper precautions are taken.

3rd Operation.—To expose in the Camera.—The exposure in the camera is effected in the usual way. The time of exposure is a matter which can only be determined by trial. The details in the deepest shadows may always be obtained by sufficient exposure; it is a mere question of time; but the lights become blue and solarized by over-exposure. It is difficult, therefore, to include successfully very violent contrasts of light and shade, and this should not be attempted as a rule, for the great charm of this process consists in the beauty of the half tones. In landscapes, however, the blue solarization of the sky is an improvement to the picture, and the b generally softens down to a warmer tone on the horizon, a charming effect.

ation.—To develop the Image.—Employ a mercury box e, provided with a thermometer. Filter about a table- mercury into the pan, through a filter with a very small ao not let the filtered mercury fall from a height into the

bath, as it oxidizes in passing through the air, and the globules on reuniting become covered with a grey film of oxide, which floats on the top, and prevents the vapour from rising so quickly as if the surface were clean.

No picture is visible when you remove the plate from the camera. Place it over the mercury, and heat the mercury with a spirit lamp to a temperature of about 140° Fahrenheit. In a few minutes the picture will be developed. The time will depend entirely on the size of the box, a large box requiring more time than a small one. From three minutes to a quarter of an hour are about the extreme limits of the time required. Remove the plate and examine it now and then by a yellow light. Push the developement as far as possible, in order to get out all the details. If you over-develop the picture, or much overheat the mercury, the shadows will be covered with minute specks or pellicles. If the plate has been exposed to too much diffused light, a white film of mercury will be deposited upon it, which will obscure the details, or injure the vigour and intensity of the blacks. If you under-develop the picture, the lights will want solidity, and the details of the shadows will be defective.

When the image has been developed in the mercury box, the plate may be exposed to moderate daylight; and the fixing process may be deferred till a convenient opportunity.

5th Operation.—To fix the Picture.—The fixing process includes two operations. The first consists in removing the coating of iodine and bromine, by means of hyposulphite of soda. The second consists in gilding the image by means of a hot solution of sel d'or which has the effect not only of improving the tone, but also of cementing the image firmly to the plate, so that it cannot be rubbed off with the finger.

Make a solution of pure hyposulphite of soda in distilled water; the strength is not material, say one ounce of hypo to ten ounces of water. Filter it carefully into a small upright glass bath, like that used for nitrate of silver. Hold this obliquely in the left hand, and let the plate slide in, with its back on the under side of the bath. We recommend this mode of immersing the plate in the hypo, because, if the plate is immersed in a horizontal bath, it sometimes happens that two waves of fluid meet in covering it, and this forms a line across the picture, which cannot afterwards be removed. If the back of the plate is dirty, it contaminates the hypo, and occasions stains on the face; hence the importance of cleaning the back of the plate. The hypo very quickly removes the steel colour of the iodine, and leaves the mercury, which forms the lights of the picture, adhering to the silvered plate, the black polished silver forming

the shadows of the picture. When the steel colour has disappeared, pour the fluid into the funnel, let the plate slide out of the bath into your hand (taking care that the face of the picture does not touch the glass), then, holding it horizontally, pour upon it filtered rain water from a bottle having a cork into which a small glass tube is inserted. This washing removes the last traces of hyposulphite of soda.

In this state, the picture may be easily wiped off the plate.

The next operation consists in gilding and fixing the picture.

Place the plate (still wet) on a levelling stand furnished with screws. Then pour upon it the following solution of sel d'or :—

20 ozs. distilled water,
1 gramme (15 grains) sel d'or.

Pour the solution into a small funnel having a tuft of cotton wool in the neck, and let it filter drop by drop upon the plate. Cover the plate with as much fluid as it will hold.

Light a spirit lamp with a large wick, and holding it underneath the plate, heat the fluid to the boiling point. Do not let the flame remain for two seconds on the same spot, but pass it rapidly from place to place, and from corner to corner. Watch the changes of tone which the picture assumes. After a few seconds it darkens slightly, and then begins to clear up. The lights become whiter, and the shadows blacker. After a time bubbles show themselves in the boiling fluid. The toning and fixing has now about reached its maximum. Do not let any bubbles adhere to the plate; a spot would occur wherever this happened. To prevent this, strike the table every now and then with your left hand, to communicate vibration to the plate, and detach the bubbles.

When the picture has been sufficiently toned, take it by one corner in a pair of nippers and pour off the fluid. Pour on it distilled or filtered rain water out of a bottle as before, and then dry it by applying a spirit lamp to the back in the following manner :—

Hold it in the nippers, inclined at an angle of about 45° to the floor; begin with drying the upper corner, and proceed gradually downwards. As the fluid dries off, a line of wet gradually recedes downwards before the lamp; follow this up by blowing on the
and remove the last drop from the lower corner by a piece of
g-paper.

ie amateur finds a difficulty in drying the plate, he may let it dry
neously, in a vertical position, resting upon blotting-paper.

picture is now finished. It cannot be rubbed off with the
; it is fast and permanent. Put it at once in the passe-par-
But, before sealing it up, blow off any dust there may be
by means of an india-rubber syringe, kept for the purpose.

It sometimes happens that the plate on drying becomes covered with minute black spots. These may be removed by a very simple method. Immerse the plate in water, put it on the levelling stand, and pour on it a dilute solution of cyanide of potassium. This will remove the spots. Wash it in water, and dry it as before. Some operators fix with cyanide instead of hypo.

The room in which the plate is sensitized should not be colder than that in which the picture is taken, or than the external air when taking a view; for, if a cold plate be taken into a warm situation, the dew condenses upon it, and, although a picture may be obtained in the mercury-box (and apparently a good picture), it is nevertheless impossible to fix or tone that picture properly, and it assumes a greenish tint, and is easily rubbed off the plate.

In order fully to appreciate the beauty of a good daguerreotype, it should be viewed in sunshine with your back to the light. The ultimate tint depends in great measure on the observance of the proportions of iodine and bromine in the sensitive coating.

A daguerreotype is permanent; the picture cannot be rubbed off the plate; the plate cannot be broken by accident; the picture will bear microscopic investigation. Other processes have their merits, but this is the triumph of the photographic art, and a boon to science.

The theory of this process is so exceedingly obscure and uncertain that at present any attempt at explanation of it would involve much that is hypothetical.

Dammar. A white resin brought from India, where it is used for various economical purposes. It is the produce of the *Pinus dammara* or *Shorea robusta,* and contains two parts, one soluble in alcohol, the other not. It is soluble in benzole, and makes an excellent varnish for positives and negatives on glass. *See* "Varnish."

Deep Meniscus. *See* "Meniscus."

Depth of Chemical Focus. Suppose a small direct pencil of white light to be refracted through a single convex lens. Since white light is not homogeneous, but composed of rays of different refrangibilities, the pencil will be decomposed by refraction through the lens into pencils of the various colours of the spectrum—red, orange, yellow, green, blue, indigo, violet; and each of these pencils will have its particular focus, the red being farthest from and the violet nearest to the lens. Let *r*, *o*, *y*, *g*, *b*, *i*, *v*, be these various foci arranged in the order in which they occur. Then, as the red, orange, and yellow rays have little or no chemical action, that action commencing with the green and terminating with certain invisible rays beyond the violet, the space between *g* and a little

beyond v is called the DEPTH OF CHEMICAL FOCUS of the lens. In a single lens the depth of chemical focus is so considerable that the lens cannot be said to have any true chemical focus, and a sensitive plate may be placed anywhere within a certain space lying between b and v, and equally good (or equally bad) pictures may be obtained.

When a lens is corrected, as it is called, for chromatic aberration, by combining TWO lenses of different kinds of glass, TWO of the foci, y and v, for instance, are united, and the other foci are brought nearer to this combined focus $y\ v$. The depth of chemical focus is, therefore, greatly diminished, and the point where the maximum of chemical action takes place is also that of the maximum of luminosity of the image. When THREE lenses of THREE different kinds of glass are used, THREE of the coloured foci may be combined; and with n lenses n foci.

When the greatest possible amount of sharpness of a photograph is desired, depth of chemical focus must be considered a defect, but when a tolerable average of definition has to be struck between the images of objects at very different distances, a little depth of chemical focus in the lens may be tolerated, because a picture in moderately good focus all over may be considered better than one which is very good in one part, and very bad in another. In general, however, depth of chemical focus must be considered a defect. A single lens is comparatively useless for photographic purposes, because of its great depth of chemical focus.

Depth of Focus. By this term is meant the fact of a lens giving equally good definitions of near and distant objects. But this quality does not depend upon any peculiarity of the lens, other than the smallness of the diaphragm used with it, or the length of its focus. The smaller the diaphragm, and the shorter the focal length of the lens, the greater will be its depth of focus. To suppose that depth of focus is a good quality possessed by certain forms of lens in a greater degree than other forms, is absurd; and yet really intelligent photographers are not unfrequently heard to exclaim, "What a marvellous lens! What wonderful depth of focus!"

ɪe term "depth of focus" is, however, sometimes used to te that near objects at the sides or bottom of a picture are in as . focus as a distant object in the centre, owing to the lens giving ırved image. But the use of the term "depth of focus" to ›te such a quality as that in a lens is decidedly incorrect, ıuse the very opposite effect to that described would be produced the same lens, if it were presented towards a set of objects so ıated as to be convex to it, instead of concave. Depth of focus in

the case described would be due rather to a happy accident than to an inherent good quality of the lens. Nevertheless, if such accidents were likely to be of frequent occurrence, it would be better to have a curved image, with well-corrected oblique pencils, than a flat field, with oblique pencils subject to great astigmation.

Development. It is somewhat difficult to give an exact definition of this term, as used in Photography. If it be defined to be the production of a visible picture from an *invisible* impression, then the term would not include the case of the printing processes in which a faint *visible* image produced in the pressure frame is intensified or developed with gallic acid. If, on the other hand, we consider development to be merely an intensifying process, then all the various methods of *toning* would come under the head of *development*, which would lead to confusion, and be objectionable. Suppose, then, we define development to be the process which immediately follows exposure, and which renders the picture visible in all its details.

In all the common development processes the image acquires fresh material. In the case of the daguerreotype process that material is mercury; in the negative processes with the salts of silver, it is silver, or silver probably combined with organic matter; in the chrysotype process it is gold; and so on. But the principle on which development proceeds is different in different processes. This will be understood by a few examples.

If a design be traced with the finger on a window pane, and we then breathe on the glass, the dew condenses on those parts which have not been touched by the finger. The design is therefore developed by steam, and rendered visible, dew being deposited on some parts of the glass and not on others; in other words, material is added to some parts and not to others. If an iodized silver plate is exposed in the camera, and then submitted to the vapour of mercury, the vapour adheres to those parts of the plate which have been modified in some way by the action of light, but not to the parts where light has not acted. The lights of the picture are therefore "brought out" or "developed" by the mercury; that is to say, the lights acquire fresh material, which renders them visible.

In the case of a collodion negative, light affects in some way those parts of the film on which it acts; a solution of a deoxidizing body, such as proto-sulphate of iron, or pyrogallic acid, is then poured over the plate; this mixes at once with the free nitrate of silver on the plate, and would at once decompose it and precipitate silver indiscriminately all over the film, were not that effect prevented for a time by acidifying the developing solution with acetic

or other acid. We have then an acidulated mixture of the proto-salt of iron, or pyrogallic acid with nitrate of silver floating upon a film, parts of which have been acted on by light. Now these parts have the property of decomposing the unstable fluid in contact with them, and of attracting in this way a precipitate of silver (or of silver combined with organic matter), which is thrown down upon *them only;* so that a visible picture is produced by *the addition of fresh material* to the parts where light has acted.

The same thing happens in the chrysotype process, although in this case the developer is not a deoxidizing but an oxidizing substance. In this process a sheet of paper is first impregnated with a persalt of iron or uranium (the per-oxalate or ammonio-citrate of iron, or the nitrate or tartrate of the sesquioxide of uranium), and then exposed to light. The metallic salt is deoxidized by light, and reduced to a proto-salt, a faint visible image being produced. The picture is then immersed in a solution of chloride of gold, which is an oxidizer, for it parts with oxygen from the water to the reduced iron salt. The liberated hydrogen unites with the chlorine, and metallic gold is precipitated of a dark purple colour. Here then, again, the picture is produced by the addition of material to the parts where light has acted.

In the alkaline development of bromized plates, the developer may be said to act by *withdrawing* material from the sensitive film, but this fact does not invalidate the definition we have given of development generally. *See* "Developer, Alkaline."

In the collodion processes, in which nitrate of silver is conjoined with an acid deoxidizer, both positives and negatives may be produced by development. In the case of a positive the picture is looked *at*, and the precipitated metal which forms the lights must be *white*. This is effected by acidifying the nitrate bath and developer with *nitric* acid, which causes pure white silver to be thrown down uncontaminated with organic matter. In the case of a negative the picture is not to be looked *at*, but printed *through*, and the precipitated material must possess sufficient density to stop the light from passing through too readily. In this case it is found that organic matter must be combined, or at least conjoined with the developer.

When protosulphate of iron is used (as it now generally is for developing negatives), it rarely occurs that sufficient printing density is obtained at the first operation. There is then necessary a second stage of development, or reinforcement of the image; and this may be done readily with a fresh supply of an acid deoxidizer containing free nitrate of silver. *See* "Ferro-gelatine Developer."

Developer, Alkaline. Until within the last two years or so, it was the universal custom to develop the negative image upon a collodion film by means of an *acid* solution of pyrogallic acid or proto-sulphate of iron; but it has been discovered by Major Russell that an *alkaline* solution of pyrogallic acid is most efficacious in the development of dry tannin plates containing bromide of silver only, or a large proportion of bromide, and from which all free nitrate of silver has been removed. Mr. Sutton subsequently found that this alkaline solution was equally efficacious in the development of *wet* collodion plates, thereby reducing the time of exposure to one half of that required when the acid developer is used. Bromide must always be used freely in the collodion, because the iodide of silver cannot be so developed; and under all circumstances of alkaline development the whole of the free nitrate of silver must have been removed from the film previous to the developer being applied. It is doubtful whether iodide of silver is of any use whatever in collodion treated by this developer.

Thus, by means of the alkaline developer, dry plates can be made as sensitive as wet ones, and ordinary wet ones twice as sensitive as before, the term *sensitiveness* being of course used in reference to the time of exposure required for the process as a whole.

One form of the alkaline developer is made thus:—To an ounce of water add 60 minims of a filtered aqueous solution of bicarbonate of soda, and twenty minims of a solution containing ten grains of pyrogallic acid to one ounce of absolute alcohol. The mixture must be used the instant it is made, because it becomes quickly decomposed. The exposed plate (having no free nitrate on it) must first be moistened, and then the alkaline developer poured over it. This brings out a faint red image, scarcely visible by transmitted light, but full of detail. The developer must then be thoroughly washed off, and the film acidified by pouring over it some extremely diluted acetic acid, to destroy the last trace of alkali which may adhere to it. After which the faint image can be easily intensified in the usual way; or, in the case of a simply bromized plate, it may be fully intensified by different doses of the same developer.

Ammonia, carbonate of ammonia, or caustic potash, may be used instead of bicarbonate of soda.

The discovery of the alkaline method of development, whereby an image can be brought out after a very short exposure, is one of the most important that has been made in Photography for many years, and when it is more thoroughly understood will work a complete revolution in *dry-plate* photography.

Deviation. When a ray of light is refracted or reflected at the surface of any medium, and follows a different course from that which it had before, the angle through which it is turned out of its original path is called its deviation. For instance, if Q R be a ray of light incident on the surface of a medium at R, and R S its path after refraction or reflection at R, then, if Q R be produced to T, the angle T R S is the deviation of the ray.

The term "deviation" must not be confounded with "aberration."

Dew; Dew Point. When a glass of iced water is brought into a warm room in summer, dew is deposited upon it, from the condensation of the aqueous vapour in the air by the cold glass. For the same reason, if a cold glass lens be taken into warm air, it becomes covered with dew; and this interferes with the production of a sharp, clear picture. Sometimes a patch of dew on the middle of a lens will produce a patch of indistinctness and fogginess in the centre of the picture. It sometimes happens also in the paper processes, that when the excited paper is placed in the slide *behind* a glass, instead of being attached to the *front* of it, the cold glass becomes covered with dew on being taken into the warm air, which of course ruins the picture if exposed before the dew has evaporated. In the daguerreotype process, also, if a cold plate is placed in summer over a warm solution of bromine, or if a cold iodized plate is taken into the warm air, dew condenses upon it, and this interferes with the production of a fine picture.

The dew point is the temperature at which dew begins to be deposited; it varies according to circumstances. The temperature of the lens, at the time of using it, should be above the dew point.

Dextrine. (Latin, *dexter*, right.) When starch is heated carefully until vapour rises from it, it becomes soluble both in cold and hot water, and loses its gelatinous character. Starch thus altered in character is called "dextrine," or "British gum," or "torrefied starch." It has the property, when acted on by polarized light, of turning the plane of polarization to the right; hence its name.

Dextrine of a pure form and very white may be made by moistening 1000 parts of dry starch with dilute nitric acid, composed of 2 parts concentrated acid, and 300 parts of water. The mixture is made into small blocks, which are first dried in the air, and then in a drying stove exposed to hot air, at a temperature of 150°. They are then pulverized, and again dried at a heat not exceeding 230°.

Another mode of producing dextrine is by the action of disastase. Dextrine is also produced by the protracted action of dilute acids at a high temperature upon starch.

Dextrine is of a pale buff colour, insoluble in alcohol, and not blued by iodine. It is a valuable substitute for gum, being more flexible and less brittle when dry. It is applied to the back of postage-stamps.

Dextrine and starch have the same chemical composition.

Diamond Cement; Chinese Cement. Soak isinglass in water until it is soft; then dissolve it in the smallest possible quantity of proof spirit, with the aid of a gentle heat. In 2 drachms of this dissolve 10 grains of ammoniacum,* and while still liquid add a solution of 2 drachms of mastic in 3 drachms of rectified spirit; stir them well together, and put the mixture into small bottles, which are to be kept covered.

When used, the cement is to be liquified by putting the bottle into hot water. The oftener it is heated, the better it gets. It resists the action of water.

Diaphanoscope. A dark box, in which transparent positives are viewed, either with or without a lens. The positive should be placed as far from the eye as the equivalent focal length of the lens with which the negative was taken; and when a lens is used for viewing it, its focal length should be the same.

Diaphragm. (Gr. διαφραγμα, a partition.) A partition with a hole in it, used in various optical instruments.

Diathermanous. (Gr. δια, through; θερμη, heat.) Heat can be transmitted through certain bodies almost without impediment, just as light through glass. These bodies are not necessarily transparent, or diaphanous, but are sometimes partially opaque to light. They are said to be "diathermanous."

Rock salt is the most diathermanous substance known; it transmits 92 per cent. of the heat rays, from whatever source they may be emitted. Sulphate of copper, which is transparent to light, is "athermanous," or opaque to heat.

Rock salt is the true glass of radiant heat. It can be cut into lenses and prisms, and used for decomposing heat by double refraction, &c.

Diffraction. *See* "Light."

Dimorphous. Substances which exist in two different forms are said to be "dimorphous." Solids sometimes change their molecular arrangement, and become dimorphous. The axles of railway carriages are made of tough fibrous wrought iron, but, by friction, vibration, and changes of temperature, they be-

* Ammoniacum is made by mixing 8 ounces of carbonate of ammonia with 2 drachms of ethereal animal oil.

come crystalline in structure and brittle. This is an example of dimorphism.

Dipper. The holder for the glass plate when immersed in the nitrate bath. It is sometimes made of silver wire, with hooks at the bottom to hold the plate; but more commonly of glass. A glass dipper should be fluted, and turned up at the end.

Dispersion. This term is used in Optics to denote the separation of a ray of heterogeneous light, by refraction, into its component rays of different refrangibility.

Different transparent media have different dispersive powers, that is, different powers of widening the angle between the red and violet rays, after the refraction of a ray of white light through a prism of given angle, at a given angle of incidence. In optical formulæ the measure of the dispersive power of any medium is a fraction, the terms of which are determined as follows:—

Let μ_v be the refractive index for the violet ray.

μ_r for the red ray.

μ for the ray of mean refrangibility.

Then the measure of the dispersive power of the medium is the fraction

$$\frac{\mu_v - \mu_r}{\mu - 1}$$

The dispersive power	of	chromate of lead is	·4
,,	,,	phosphorus	·128
,,	,,	oil of cloves	·062
,,	,,	flint glass	·052
,,	,,	Canada balsam	·045
,,	,,	diamond	·038
,,	,,	crown glass	·034
,,	,,	alcohol	·029
,,	,,	rock crystal	·026
,,	,,	fluor spar	·022

In an achromatic lens, formed of two single lenses in contact, the focal lengths of the single lenses are proportional to the dispersive powers of the respective glasses.

Dispersion, Irrationality of. "By measuring the spectra in Fraunhofer's manner, it is found that the distance between any, the same two fixed lines of the spectrum has not a constant ratio to the distance between the extreme fixed lines where different media are used. This circumstance is called the 'Irrationality of Dispersion.'

"If refracting media had no irrationality, then, in providing a combination such that two given lines should not be separated, we

should at the same time unite lights of all species. But, since the colours are disproportionately dispersed in different media, the other lines will, in such a case, be very nearly, but not exactly united." (Griffin's "Optics," pages 95 and 100.)

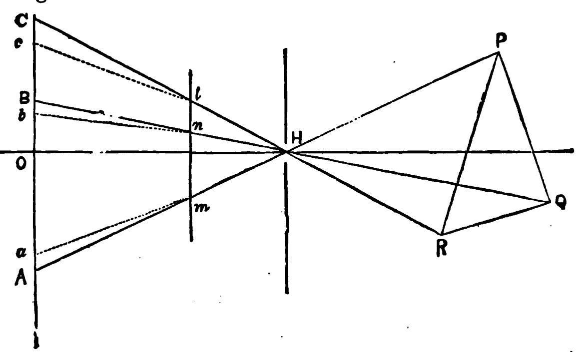
Dissolving Views. *See* "Magic Lantern."

Distillation. The vapourizing, by heat, of liquids in a retort or still, and subsequent condensation by cold in a receiver.

To photographers distillation renders invaluable service, because it enables them to purify many liquids from foreign matter which would inevitably frustrate all their efforts to *paint with the sunbeam*. For instance, by its means water containing injurious organic and inorganic salts is entirely freed from them; because, while the water passes over in vapour, and is again condensed in the receiver, the impurities remain behind in the retort. Or, again, distillation may be used for separating two liquids which have different boiling points, alcohol and ether, for example, or alcohol and water.

Distortion. When the image formed by a lens on the focussing screen of a camera obscura does not satisfy the conditions imposed by the rules of perspective, it is said to be distorted.

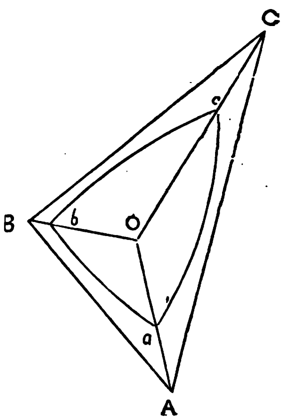
Distortion of the image in the camera is in general produced by the excentrical incidence of the oblique pencils. Its effect is to render all straight lines which do not pass through the centre of the picture curvilinear, and also to exaggerate the dimensions of certain objects in the picture, with respect to others, in a way which is opposed to the principles of true perspective. We shall explain how distortion arises when a large view lens is used with a diaphragm in front, as this arrangement offers an illustration of the evil in a very marked degree.



Suppose P Q R to be a triangle placed in front of a large view lens *l m*, having a diaphragm in front at H. First let the lens be removed, and the size of the aperture at H be reduced indefinitely. Then images A, B, C, of the points P, Q, R, will be formed on the focussing screen by producing the lines P H, Q H, R H, until they cut it, and the triangle A B C on the focussing screen will be a correct perspective view of P Q R, as seen from the point H.

Now introduce the lens *l m*.

The small oblique excentrical pencil P H, incident at *m*, is bent out of its course by refraction through the margin of the lens, and comes to a focus at *a*. Similarly, the pencils from Q R, have their foci at *b*, *c*. The image given by the lens is, therefore, the triangle *a b c*. This triangle is smaller than A B C; but, if the distance A *a*, B *b*, C *c*, are proportional to O A, O B, O C, the two triangles will be similar figures, and there will be no distortion. It happens, however, that the decrements A *a*, B *b*, C *c*, are not proportional to the radial lines O A, O B, O C, but increase more rapidly than these do. There is, therefore, distortion of the image, as shown in the figure.



The distortion produced by the orthoscopic lens is of the opposite character, and is called "pincushion distortion," because marginal lines in the picture, which should be straight, are rendered convex towards its centre, like the sides of a pincushion. Distortion may be almost entirely got rid of by using a double or triple combination in which the diaphragm is so placed between the front and back lenses as very nearly to divide the space between them in the ratio of their focal lengths. In a perfectly symmetrical doublet or triplet, the emergent rays form a system exactly parallel to the incident rays, each to each; nevertheless, there will still be some slight distortion of the image, except in the case in which a flat object is copied full-size by the lens. The parallelism of the two systems of rays is not enough to constitute absolute freedom from distortion of the image. There is another condition necessary; viz., that the axes of the pencils should suffer no displacement in their passage through the lens. The only lens at present known which perfectly satisfies the

theoretical conditions of absolute freedom from distortion is the panoramic lens invented by the writer. Nevertheless, in a properly-constructed doublet or triplet, the practical amount of distortion is quite inappreciable.

The indistinct image of external objects that is formed upon the wall of a darkened room by a small hole in an opposite window shutter is entirely free from distortion. Indistinctness and distortion are quite different things, and the terms must not be confounded.

When, in a portrait, the hands or feet of the sitter appear too large in proportion to the face, it is not always correct to call that apparent defect distortion. The whole figure may be in perfectly true perspective when viewed from the proper point.

Double Iodide. By this term is generally meant "double iodide of silver and potassium"—that is, a solution of iodide of silver in iodide of potassium; a *very strong* solution of iodide of potassium being capable of dissolving a *small* quantity of iodide of silver.

Double iodide is used in the calotype process, and is made thus:—

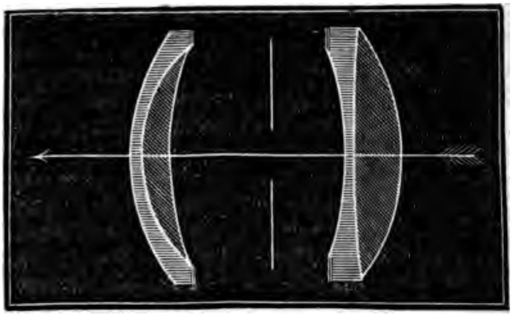
Dissolve in one measure 20 grains of nitrate of silver in about an ounce of distilled water (the quantity is not material), and in another measure dissolve 20 grains of iodide of potassium in about the same quantity of distilled water. Mix the solutions. The mixture immediately becomes yellow and turbid, and a yellow precipitate, which is iodide of silver, soon subsides. Pour off as much as possible of the liquid (which contains nitrate of potash), then add an ounce of distilled water to the precipitate, and as much iodide of potassium in crystals as will completely dissolve it, and render the solution colourless, *but no more.* The quantity required will be about 200 grains. Shake well after each addition of fresh crystals, and wait till they are dissolved before adding more, proceeding cautiously towards the last.

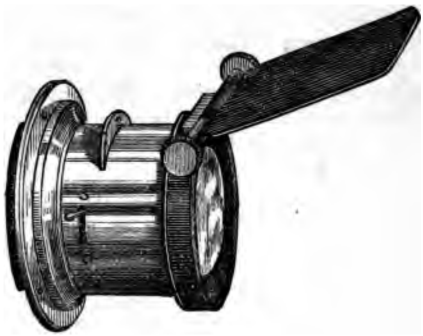
Double iodide is rendered turbid by the addition of water, but the turbidity may be removed by adding crystals of iodide of potassium.

Double Refraction. *See* "Light."

Doublet. A new view lens, invented by Mr. Thomas Ross in the year 1863, and now coming extensively into use, and superseding all other forms of lens for landscape and copying purposes. It includes the widest field of view upon a flat plate of any known lens, with the best marginal definition, and perfect freedom both

from flare and from distortion. Its optical construction and its mounting are shown in the following figures:—





The direction in which light passes through it is indicated by the arrow. Each lens is an actinic cemented compound, and they are nearly equal in focal length, and of the deep meniscus form, with a stop placed nearly midway between them. It is the deep hollow of the inner surfaces of the two meniscuses which gives flatness of field by lengthening the oblique refracted pencils; while the methods employed for achromatising those lenses effect in the best possible way the corrections for astigmation of the oblique pencils. A field of view, including 70° of angular extent, is beautifully covered by one of these instruments, when a stop, having a diameter equal to the one-thirtieth of its equivalent focal length, is used. Pictures taken with this lens are remarkable for their brilliancy, equality of illumination, breadth of field, absence of distortion, and perfection of

definition. The Ross doublet is a lens which no landscape photographer should be without. It is a perfect marvel of optical science; and, so far as we can see, not likely to be surpassed. The mechanical appliances for shifting the diaphragms, and shading the front lens, leave nothing to be desired in that direction.

Dry Collodion Processes. A collodionised glass plate may be rendered sensitive to light, and used either in a wet or a dry state, with an equally short exposure in both cases, and with equally good results, if the respective operations are conducted on correct principles. It is only quite recently, however, that these correct principles have at length been established, thanks to the laborious researches of Major Russell, in the theory and practice of the dry processes.

In the wet collodion process the extreme sensitiveness is mainly due to the presence of the free nitrate of silver, which is contained in the bath solution that clings to the plate; for, if this be removed by washing, the plate loses a great deal of its sensitiveness. The collodion, however, which is used in the wet process contains but a small quantity of a soluble bromide in proportion to iodide; and therefore the sensitiveness of the plate depends chiefly on the presence of iodide of silver, plus a large excess of free nitrate of silver in the film. This condition cannot, however, be maintained in the dry process, for if a collodion plate, excited in the usual way, is allowed to get dry, without having previously washed off the free nitrate of silver, the yellow layer of iodide of silver disappears, and the film becomes transparent and insensitive. This arises from the fact that iodide of silver is soluble in a *concentrated* solution of nitrate of silver; so that, as the moisture evaporates from the film, the free nitrate becomes concentrated, and dissolves the iodide of silver, forming a double salt, which has been called nitro-iodide of silver. In order, therefore, to use the collodion film in a dry state, it is found necessary to remove either the whole, or the greater part of the free nitrate of silver by copious washing. If, then, the same collodion and developer were used for a dry plate thus treated as for a wet one, there would, of course, be a great loss of sensitiveness in the dry plate; but it fortunately happens that bromide of silver is very different in its action in some important respects from iodide of silver; and therefore, by availing ourselves of the useful properties of bromide of silver, we are able to avoid the above inconvenience of comparatively insensitive dry plates. In other words, the collodion for the dry processes must contain a much larger proportion of a soluble bromide *than that* for the wet process, inasmuch

H 2

as in the latter you depend chiefly for sensitiveness upon iodide of silver plus free nitrate, and in the former, upon bromide of silver alone, or at any rate in a much larger proportion to the iodide than before.

The principle on which the dry processes are based—those at least in which the dry plate is as sensitive as a wet one—is this:—To use a suitable collodion, containing sufficient soluble bromide, to remove all the free nitrate of silver from the sensitive plate, and to develop the image by the alkaline, and not by the common acid developer. There are, however, certain dry processes; for instance, the "New Fothergill," and "Gum," in which a trace of free nitrate is left on the film, and which yield good results with a short exposure.

In addition to the use of a special collodion, there is another condition of success in the dry processes, which consists in applying to the film, after it has been washed, a solution which has been absurdly called the "preservative," the office of which is to supply the organic matter necessary to produce a dense and clear negative. A great variety of substances have been employed for this purpose, and most of them appear to act well when the other conditions of success are present. The preference is generally given to albumen and tannin, with or without the addition of honey, the use of the honey being to prevent the perfect desiccation of the film.

The most rapid dry collodion processes recommended are the tannin and the New Fothergill, both with alkaline development; and the collodio-albumen for slow work. These will be found fully described under their respective heads.

Dyeing. The principles of dyeing and calico printing may be included shortly in those of Photography, from the fact that certain chemicals are capable of becoming mordants by exposure to light. The object of dyeing is to produce a permanent combination between the material to be dyed and the colouring matter. This combination is effected by means of a mordant, which combines chemically with the stuff to be dyed, and at the same time with the colouring matter, forming, so to speak, a triple combination. Without the mordant, the colouring matter might, of course, be removed from the fabric by washing it in water, since it would offer a mere case of mixture, and not of chemical combination.

It is found that bichromate of potass has the property of becoming mordant by exposure to light, and this property has already been en advantage of by calico printers in Paris, to print designs upon tile fabrics by means of Photography. If a piece of paper be

rubbed over with a little indigo mixed with bichromate of potass, dried in the dark, and exposed under a negative, the parts acted on by light are permanently fixed, while from those not acted on the colour may be removed by washing the paper in water.

Processes of this kind offer a new and important field of research.

The principal dyes are indigo, cochineal, madder, quercitron, logwood, annatto, lake, prussian blue, various salts of iron, copper, lead, chromium, cobalt, and the aniline dyes. The principal mordants are proto-chloride of tin, alum, sulphate of iron, &c.

Dynactinometer. An instrument for measuring the intensity of actinic power, or for comparing the "quickness" of lenses. *See* "Hunt's Treatise on Photography."

Earthenware, Glaze for. As earthenware vessels are much used in Photography, the mode of glazing them should not be disregarded, as some of the chemicals (nitrate of silver, for instance) act on the glaze.

The common white dishes are glazed with

White lead	53 parts.
Cornish stone	16 ,,
Ground flints	36 ,,
Flint glass	4 ,,

Stone ware is glazed with a mixture similar to the above, but containing also red lead. The materials are pulverized, and then mixed into a paste with water; this is spread upon the vessel to be glazed, which is then submitted to the furnace, which vitrifies the glaze.

Eau Bromee. Bromine water, formerly used in the daguerreotype process, but now superseded by bromide of lime, because in hot weather the vapour from the bromine water condenses on the cold plate, and interferes with the production of a good impression.

Ebonite. A hard, black, ebony-like substance, prepared by combining sulphur with caoutchouc. It is admirably adapted for photographic washing trays, for which it is now used to some extent. It is also used for nitrate of silver dipping baths; but it can scarcely be recommended for this purpose, because, while it possesses the great advantage over glass of being less fragile, it is likely to contaminate the contained solution with sulphur and organic matter.

Efflorescence. When a crystallized salt parts with its water of crystallization by exposure to dry air, and crumbles into a powder, it is said to "effloresce." Sulphate of soda is an instance of this property.

Eggs. The albumen obtained from eggs is much used in Photography. The yelk of the hen's egg contains about 30 per cent. of oil, in which phosphorus is present. New-laid eggs are heavier than water, but gradually become lighter by the evaporation of water through the shell. Of an egg which weighs 1000 grains, 106·9 parts constitute the shell, 604·2 the white, and 288·9 the yelk.

Electrical Images. *See* "Moser's Experiments."

Electro-Chemical Action of the Solar Rays. Mr. Robert Hunt has, from some experiments, arrived at the following conclusions:—

1st.—"That electro-metallic precipitation is prevented by the sun's rays."

2nd.—"That light is not the retarding agent; but the exercise of electrical force is negatived by the direct influence of actinism."

Elements. The elements, or elementary bodies, are such as have hitherto resisted all attempts to reduce them into simpler forms of matter. They are indefinite in number, but those already known to exist will be found arranged in alphabetical order in the Table at the end of the work.

Elemi. This is a species of resin much used in varnishes. There are several varieties of it. The principal are obtained from the *Canarium balsamiferum* of Ceylon, and the *Icica icicariba* of the Brazils. Elemi is at first soft and viscid, but becomes hard and brittle by cold and age. It is yellow, translucent, and of a peculiar odour resembling fennel. It contains 60 parts per cent. of an acid resin soluble in cold alcohol, and 20 parts of an indifferent crystallisable resin soluble in hot alcohol.

Elliotype Process. A process patented by Mr. Robinson Elliot of South Shields, for enabling artists to obtain an indefinite number of photographic copies of their works.

A painting is made upon glass in a body colour, more or less transparent according to its density, and the thickness with which it is applied. The painting is then treated as a negative, and positives are printed from it in the usual way.

Emery. A dark-coloured mineral, found in abundance near Cape neri, in the island of Naxos. It occurs also in the Channel Islands, land, Sweden, Persia, &c. According to Mr. Tennant's analysis, is composed of alumina, 80 parts; silica, 3 parts; iron, 4 parts. hen reduced to powder, emery varies in colour from dark grey to ıck. Examined under the microscope, the powder is seen to be

composed of two crystals; viz., corundum and oxide of iron. This powder is so hard as to scratch quartz and many precious stones. It is used in the arts for grinding, polishing, and scouring articles of metal, glass, &c.

Emery Paper; Emery Cloth. Emery powder may be spread upon paper or cloth by first applying a coating of thin glue, and then dusting the powder over it from a sieve. There are six degrees of coarseness. To use emery paper, it should be wrapped round a stick and a little oil applied, which makes it cut better. Emery cake is made by mixing emery powder with bees-wax.

Razor-strop paper is made by mixing the finest emery powder and a little finely powdered glass with paper pulp, and making it into sheets in the ordinary way. This should be glued to a piece of wood, and a little oil applied occasionally. The emery and glass constitute more than half the weight of the paper.

Enamelled Photographs. In the "Comptes Rendus" of June 11, 1855, various methods of producing enamelled photographs are described by M. A. Lafon de Camarsac. The following translation of this article is extracted from the Journal of the Photographic Society for September 21st, 1855:—

"I select for grounds either metals, or substances used for pottery; I use vitrifiable compounds for tracing the image on them; and I operate both on the images obtained by the use of metallic salts and those furnished by the resins.

"With pictures produced by the aid of collodion, albumen, gelatine, and by the ordinary processes of the salts of silver, I develop the image by nitrate of silver until the half tints are overdone and obscured, and the deep shades are covered with a thick deposit presenting the appearance of a bas-relief. The proof is then placed in an enameller's muffle; the organic matters vanish under the action of a suitable temperature. The fire cleans the image and restores all its delicacy.

"I operate on white grounds, or black, or coloured grounds. On tinted porcelain, coloured glass, or on brown or black enamel, the whites of the image are formed by the deposit of reduced metal, which acquires great brilliancy in the furnace. On white porcelain, or enamel, or on transparent glass, the blacks of the image will be formed by the metallic deposit, which I then treat with solutions of salts of tin, salts of gold, or salts of chromium. In the latter case I obtain various colours, very vigorous when removed from the muffle, presenting a peculiar semi-metallic brilliancy. A very thin layer of an appropriate and very fusible flux fixes the image on the ground,

as in the case of applying gold or silver to porcelain. On enamel, the fusion of the matrix itself fulfils the same office.

"With regard to images obtained by the action of light upon salts of chromium,—as soon as the image is cleaned by distilled water I expose it in a muffle to a temperature which destroys the gelatine; the metallic deposit remains alone upon the ground. Salts of silver and of lead laid on this give yellow tints after baking; salts of tin and of gold produce violets and purples. These colours are developed under a layer of flux which here covers the metallic deposit. The image presents the appearance of a painting on porcelain.

"The pictures furnished by resins are treated differently. I compound a coating capable of receiving application of a negative, and of being easily rendered sticky after the exposure to light. Solution of bitumen of Judæa in essence of turpentine, with the addition of resin, fulfils this requirement. The exposure to light being finished, and the solvent having performed its office, I proceed to the substitution of ceramic colours for this varnish, which must be destroyed by the fire. Metallic oxides and their fluxes, ground very fine and dried, are deposited on the surface of the image, while a gentle and graduated heat restores to the coating the adhesive property it had lost in drying. These enamel powders, carried over the entire surface of the picture, follow with great delicacy all the inequalities of the subject, which they partially penetrate, and translate faithfully all its depths and delicacies. The piece is then ready for the fire; the organic matters are destroyed, and the image, formed of indestructible substances, remains fixed by vitrification.

"One of the remarkable characters of these images is the aspect of under-enamel (*sous-émail*) which they present, which cannot be furnished in the same degree of perfection by any other kind of painting.

"The heliographic image thus treated may receive any kind of colouring: it may be transformed into gold or silver as well as into blue or purple; it may even be burnt into porcelain with the furnace colours.

"Observing that, in the same image, the light, in tracing the bright parts, left a faithful image of the shadows, and that the entire negative *cliché* might be transformed into a positive *cliché*, I was led to combine two opposite and successive impressions of the same image. By taking from one of these impressions all the light tints, and from the other all the dark ones, I obtained the image of the lights (defined) by the shades, and of the shades (defined) by the lights, with the infinite variety of tints resulting from the combination."

The photographic enamels which have been exhibited by M. Lafon de Camersac, in Paris, London, and elsewhere, are beyond all approach the best works of the kind that have yet been seen. Whether these were done by the process above described, it is, however, impossible to say, as he declines to publish his present method.

Enamelled photographs may be produced by Mr. Pouncy's bitumen process. *See* "Carbon Processes."

Enamelled Photographs upon Glass.—Joubert. M. Ferdinand Jean Joubert de la Ferté took out a patent for reproducing designs on glass, ceramic, and other mineral surfaces, which was sealed April 11th, 1860. The following is a brief account of his process as more fully described in his specification:—

A sensitive solution, composed of 1 oz. of bichromate of ammonia dissolved in 4 ozs. of water, is first made and filtered. To 5 parts, by measure, of this is added another solution, composed of 3 parts, by measure, of honey, three parts of albumen, and 30 parts of water.

The above sensitive solution is poured over the plate, and dried gently by artificial heat; after which it is exposed to light under a transparent positive print, for about a minute if the light is strong. The result is a visible negative image upon the plate. This image is then rubbed gently up and down with a large camel-hair brush charged with well-divided enamel, or vitreous colour, of the tint required, until the image has become a distinct and perfect positive, on looking at it by transmitted light, in consequence of the enamel powder sticking only to those parts where the light has *not* acted on the sensitive film. The glass plate is then washed thoroughly with alcohol slightly acidified with acetic or nitric acid; and the film is left to dry slowly. When dry it is immersed in water. The yellow tinge of the film is soon removed by this treatment, and the image upon the glass appears perfectly clear, and free from any foreign substance. The plate is then dried, and placed in the muffle to be burnt.

M. Joubert has exhibited many beautiful specimens done by the above process; but, for some reason or other, it does not seem to have proved in his hands a commercial success, nor does it seem, from his manner of conducting his operations, that it is likely to become so.

Enamelling is also applied, although improperly, to another class of photographs on paper, so treated as to protect them from air and moisture, and thus probably prevent them from fading. The

appearance of enamelled paper prints resembles very much that of real enamels—hence probably the name. Mr. Wenderoth, of Philadelphia, has been most successful in this process. The following is his method of procedure :—

First rub over a clean plate glass some white bees'-wax dissolved in ether; then coat with collodion, and when dry pour on it a solution of gelatine 2 ounces, water 16 ounces, glycerine 12 drops to each ounce of solution. Put the plate down horizontally, and let it become perfectly dry. Immerse the print which is to be enamelled for half an hour in alcohol of 93° four parts, distilled water 1 part. Then just before putting the picture on the gelatine take a large flat camel's-hair brush and moisten the gelatine surface with the alcohol and water mixture; then take the picture from the alcohol and lay it quickly down on the gelatine, commencing at one end. No air bubbles are produced in this manner, and by passing with the camel's hair brush over the back of the picture the surplus alcohol is removed.

The mounting, for the purpose of stiffening the picture, is done almost in the same way. When the picture is perfectly dry, pour over its back the same gelatine and glycerine preparation, but only half as strong as the other, and let it get dry. Immerse the mount in the same alcohol and water for half-an-hour, and then lay it down on the gelatine. But no matter how thin the mount is, it will diminish the brilliancy of the enamel just in proportion to its thickness.

Great care should be taken that the wax coating has covered every part of the glass, or the print will not come off entirely, but stick and tear.

Encaustic Painting. This method of painting, which is of great antiquity, consists in using wax with the colours, in order to give them a gloss, and preserve them from injury. Proceed thus :—

Melt together equal quantities of white wax and powdered mastic, stirring well. Pour the melted mixture into cold water, which hardens it; then pound it in a mortar. This powder is to be ted with strong gum arabic, and added to the common water-urs, which are then to be used at once in the ordinary way, ted with water as occasion may require, and applied with a brush. pale colours require least, and the dark ones most, of the powder s added to them. The picture must be very highly and care-finished. It is then to be varnished with a mixture of one white wax, and two parts turpentine, applied hot, and the rfluity allowed to run off.

The wood, or cloth, or paper to be painted upon must first be waxed.

Engraving, Heliographic. The processes of heliographic engraving have not yet been brought to sufficient perfection to be worthy of more than a few brief remarks in this dictionary.

M. Nicéphore Niépce availed himself of the property possessed by bitumen of Judæa, of being rendered insoluble in the usual menstrua by the joint action of light and oxygen. A metal plate was coated, in the dark, with a solution of bitumen in a solvent, dried, and exposed to light under an engraving, or in the camera. It was then washed with the same or other efficacious solvent, which removed the bitumen where light had not acted, and permitted it to remain where light had rendered it insoluble. The bare metal thus exposed was then etched with an acid, and an engraving produced.

This process was followed up by M. Niépce de St. Victor, and some improvements made in it, which will be found described at different times in his communications to the French Academy of Sciences. Although very interesting, these communications are not as yet of much practical importance.

Mr. Fox Talbot, a few years ago, obtained some little success with a rather different, and, we imagine, a better process. He coated a steel plate with a mixture of gelatine and bichromate of potass, and exposed it to light under a negative. Where the light acted on this mixture, it reduced the salt of chromium, and caused it to combine with the gelatine, thereby producing a compound which was insoluble in water. The plate was then washed with water, which removed the unaltered gelatine only. A picture was in this way produced upon the plate, which was etched by a solution of bichloride of platinum, which attacked only those parts where the metal was not protected by the gelatinous compound.

MM. Salmon and Garnier have suggested a process of heliographic engraving different from either of the preceding, and which appears very ingenious.

"If a polished plate of brass, previously submitted to the action of iodine vapour, is exposed to diffused light, and then rubbed with wadding, charged with globules of mercury, the following phenomena will be observed—the plate will not be amalgamated, the mercury refusing to attach itself wherever the iodine has been influenced by light. If, instead of proceeding thus, the plate is covered in places with an opaque body, and we then try to amalgamate it as before, it will be observed that the mercury takes perfectly on the parts where light has not acted, while it refuses to

adhere in other places. This property discovered by MM. Salmon and Garnier, indicates the possibility of reproducing photographic images upon a plate of brass. A negative on glass, or paper, is applied to the iodised brass plate, and left in contact from ten minutes to two hours in diffused light. On mercurialising the plate, the mercury is seen to adhere to those parts which correspond to the blacks of the negative, leaving the other parts intact. If an ink-roller is then passed over, the untouched parts take the ink, while the mercurialised parts do not, so that the picture is black upon a white ground.

"An etching may then be produced by first dissolving out the mercury, by means of a solution of nitrate of silver acidified with nitric acid, and then biting in the plate still deeper by acid alone. If, on the other hand, an engraving is wanted for printing in a lithographic press, the plate is immersed for a few minutes in a galvanic bath charged with chloride of iron so as to deposit a thin layer of metallic iron in the places previously occupied by the mercury, and where the brass is now bare, namely, on the lines of the drawing. The utility of this deposit of iron will soon be perceived. The brass plate being removed from the bath, the greasy ink is dissolved off with spirits of turpentine. The entire plate is then exposed again to the vapour of iodine, and rubbed with wadding bearing globules of mercury; whence it results that the plate, as before, acquires a white colour, from the amalgam of mercury; but as this metal does not amalgamate with iron (for mercury is preserved in iron vessels), a mere gentle rubbing of the plate removes it from the places covered with iron, that is to say, from the drawing itself: so that after the second operation the drawing has the lines covered by a thin layer of iron, while all the rest of the brass plate is coated with mercury.

"Things being in this state, the ink-roller is passed over the plate; only the drawing itself takes the ink, while those parts coated with mercury repel it. This is just what was required. As many impresions as desired may now be printed, only taking the precaution to rub the plate afresh with mercury after a certain number of impressions have been thrown off. If it be wished, indeed, the two last operations might be omitted: it would suffice to wet with water the plate once inked with greasy ink, as done by the lithographic printers; under these circumstances the parts free from the drawing would be isolated by water, which would prevent the greasy ink from touching them.

"Supposing now that instead of a plate to be printed in a lithographic press, it is desired to have one that may be printed with

letterpress, the following will be the mode of procedure:—Taking the plate at the moment when it is about to be immersed in the galvanic bath, a preparation of gold should be substituted for the salt of iron, and a thin layer allowed to deposit over the drawing (it will take the gold because it resists the action of the acids better); the plate is then inked and eaten away all round the lines, which will be preserved by the gold, the surrounding copper only being attacked, so that the drawing itself will be found in relief."

Equivalent. On referring to the table of Elementary Substances the reader will observe that against every substance a certain number is placed, called its "Equivalent," or sometimes its "atomic weight." For instance; silver has the equivalent 108, iodine, 127, carbon 6, sulphur 16, and so on. The meaning of these numbers we will endeavour to explain.

It is found by experiment that substances combine with one another only in certain definite proportions by weight; and, reasoning on this fact, it has been supposed that matter is not indefinitely divisible, but that bodies are composed of atoms incapable of being divided into smaller fragments, and therefore called "ultimate atoms," these ultimate atoms being of different weight in different bodies. On this hypothesis, the equivalent of any elementary body is the weight of an ultimate atom of that body, the unit of weight being of course indefinitely small, but the same for all substances; and the equivalent of a compound body is the total weight of all the single atoms composing the compound atom. If, then, we say that the equivalent of silver is 108, we mean that an ultimate atom of silver weighs 108 units of weight; and since in the same scale the equivalent of hydrogen is 1, it appears that the unit of weight in that scale is the weight of an ultimate atom of hydrogen.

But this explanation of the meaning of the table of equivalents involves a hypothesis which, however reasonable it may appear, may nevertheless be false, and is after all *but* a hypothesis. If then we reject the explanation given according to this hypothesis, and confine ourselves to the facts of the case, the table of equivalents becomes merely a table of the proportions by weight in which different bodies are found to combine.

In order to show the utility of this table, take the following examples:—

1st. In an apothecaries' ounce (480 grains) of chloride of silver, how many grains of silver and how many of chlorine are there?

The equivalent of silver is 108, of chlorine, in round numbers, 36; the equivalent of chloride of silver is therefore 144. If then, we

multiply 480 by 108, and divide by 144, we get the number of grains of silver in the ounce of chloride, viz. 360; and if we multiply 480 by 36, and divide by 144, we get the number of grains of chlorine, viz. 120. There are, therefore, in an ounce of chloride of silver 360 grains of silver, and 120 grains of chlorine.

2nd Required to know how much iodide of potassium will exactly decompose one apothecaries' ounce (480 grains) of nitrate of silver, neither of these salts containing any water of crystallisation.

Nitric acid is composed of 1 part nitrogen and 5 parts oxygen by weight. The equivalent of nitrogen is 14, of oxygen 8. The equivalent of nitric acid is therefore 54, and of oxide of silver 108 + 8, viz., 116. The equivalent of nitrate of silver is therefore 116 + 54, viz. 170.

Iodide of potassium is a salt containing no water of crystallisation. The equivalent of iodine is 127, and of potassium 39; and therefore of iodide of potassium 166.

In the decomposition of nitrate of silver by iodide of potassium, there are formed nitrate of potash and iodide of silver. If, then, we multiply 480 by 170, and divide by 166, we obtain the exact number of grains of iodide of potassium necessary to effect the decomposition, viz. $491\frac{4}{8}$.

A Table of Equivalents of the simple substances will be found at the end of the work.

Equivalent Focal Length. Suppose that a lens, or combination of lenses, when presented towards a distant object, renders the image of it a certain size upon the ground glass. Then the "equivalent focal length" of that lens, or combination of lenses, is equal to the principal focal length of a single lens, having a small stop in close contact with its central portion, which gives the same sized image of that object, when taken from the same point of view.

The size of an image formed by a single lens, such as that described above, is always proportional to the focal length of the lens. Hence many simple practical methods of finding the equivalent focal length of a combination of lenses will occur to the reader.

In what has been said, it is assumed that the image formed by the combination is free from distortion; otherwise the statement will not be strictly correct. In order to reduce the error due to distortion, the object should be such as to include only a small angle at the lens.

Ether. Oxide of ethyle. $C_8 H_{10} O_2 = 74$.

Alcohol is supposed to be a hydrate of ether, two volumes of alcoholic vapour being composed of one volume of aqueous vapour

and one of the vapour of ether. If, then, alcohol be decomposed, and the elements of water removed, the result is the production of ether. Such is the theory of etherification.

Ether, or, as it is frequently called, "sulphuric ether," is an extremely volatile, colourless, combustible, fragrant liquid, obtained by distilling together alcohol and sulphuric acid. It is of great use in Photography as a solvent of pyroxyline.

The manufacture of ether is an extremely dangerous operation, and should not be attempted by the amateur. The mode in which it may be made, either on a large or small scale, with the proper precautions is as follows:—

A large flask contains the mixture of alcohol and sulphuric acid. It has a stopper with three holes in it: through one is inserted a thermometer tube, through another the pipe which leads to the condenser, and through the third a tube through which a fresh supply of alcohol is kept up. The flask is placed in a sand bath, and heat applied, which may be regulated as required.

In using the apparatus, a mixture of 8 parts by weight of concentrated sulphuric acid, and 5 parts of alcohol sp. gr. ·834, is put into the flask and heated till it boils and rises to a temperature of 300° Fahrenheit. Fresh alcohol is then introduced as required, and this temperature evenly maintained, the liquid in the flask being kept in rapid ebullition. The bulk of the liquid in the flask is in this way kept up for any length of time, and every drop of alcohol introduced is converted into ether and water, the mixed vapours of which go over together through the condenser into the receiver, where the ether floats upon the surface of the water. When the operation is properly conducted, the same quantity of sulphuric acid is sufficient for any amount of alcohol that may be added to it. The limits of the ether-producing temperature are between 260° and 310°: if the boiling point should fall below 260° by using too much alcohol or too weak acid, little else than unchanged alcohol distils over; and if, by using too much sulphuric acid, the boiling point rises above 320°, olefiant gas is generated, besides variable quantities of other impurities.

Ether will take up one ninth part of its bulk of water, and will mix with alcohol in any proportion. In order to obtain pure ether, free from both alcohol and water, it is first mixed with about twice its volume of water, and well shaken; this separates the alcohol, which leaves the ether, and goes to the water. The ether, which floats on the water, is then carefully decanted, and a sufficient quantity of fresh-burned lime added to it: this abstracts the water. The mixture is then distilled with great care, the receiver being

surrounded with ice and carefully stopped. The first third which distils over is pure ether.

The sp. gr. of pure ether at 60° Fahrenheit is ·720. It boils at 98° Fahrenheit, at the mean pressure of the atmosphere. It is neither acid nor alkaline, has a high refractive power in regard to light, and is a non-conductor of electricity. It is extremely volatile, and its vapour very dense and highly elastic. Ether burns without leaving a residue, and produces carbonic acid and water. It should be kept in well-stoppered bottles, as it turns acid by contact with air, from the production, first, of acetic ether, and subsequently, acetic acid.

Iodine and bromine are soluble in ether, and gradually react upon and decompose it, producing hydriodic and hydrobromic acids.

Ammoniacal gas and hydrochloric acid gas are readily absorbed by ether. Potash and soda act feebly upon it, and give rise, among other products, to acetic and formic acids, which unite with the alkali. Many salts are soluble in ether, and especially the chlorides of gold, platinum, iron, and uranium.

The fixed and volatile oils, many of the resins, caoutchouc, various forms of extractive, the alkaloids, and some other vegetable principles, are more or less soluble in ether.

The chief use of ether in Photography is to dissolve pyroxyline so as to form collodion.

By adding a variety of different acids to alcohol, and distilling the mixture, corresponding varieties of ether are produced. Hence we have nitrous ether, oxalic ether, hydrochloric ether, acetic ether, and so on. As none of these ethers are at present of any use in Photography, it would be out of place to describe them in this work.

A table indicating the quantity of alcohol contained in ether of variable specific gravity will be found among the tables at the end.

Ether (Methylated). This preparation is now extensively used in the manufacture of collodion. When properly rectified and purified, it answers quite as well as the other, and, from its being very much cheaper, it has therefore almost entirely superseded the ether prepared from pure alcohol.

Methylated ether absorbs iodine, forming, most probably, iodide of methyl. Hence iodised collodion prepared from it will preserve its proper colour for many months, even in the light, although, perhaps, it is not quite so sensitive as it was at first. It has been said that this ether contaminates the nitrate bath quickly with organic matter. This is quite true if the crude ether is employed, but by a system of purification through charcoal it may be rendered quite harmless. If

methylated ether smells of wood spirit, it should never be used for making collodion, because then it deteriorates the nitrate bath rapidly.

Exosmose. When two fluids of different densities are separated by a vegetable or animal membrane, the denser fluid seems to have the power of attracting the less dense one through the membraneous tissue. On this principle can be explained the blistering of collodion films, and of albumenized paper when placed into water after being taken from the hyposulphite fixing bath. In the latter case the dense hyposulphite solution is *in* the paper, and attracts the less dense water from without in such quantity as to raise up the albumen coating from the paper.

Exposure. The exposure of a sensitive surface to light, either in the camera or pressure frame, is one of the most important features of every photographic process; and we shall endeavour to describe in this place the effects due both to *over* and *under* exposure in the principal processes, and as far as possible to account for them satisfactorily.

The simplest case is that of sun-printing upon chloride paper. Here a sensitive surface consisting of chloride of silver, nitrate of silver, and organic matter is exposed to direct light until a visible image of the required strength is obtained. The effect of light on such a surface is to decompose it and produce a dark material composed of subchloride of silver, together with a compound of suboxide of silver and organic matter. When the image thus obtained, and which is of a purple-brown tint, is put into the bath of hyposulphite of soda, in order to fix it by removing the unaltered chloride of silver, the grey subchloride in the image is also decomposed into chloride of silver and metallic silver, and the former is dissolved out. The fixing bath therefore not only removes the superfluous chloride in the paper, but also enfeebles the dark tint of the shadows of the picture, by changing it from a deep purple to a red or brown. When sufficient allowance is not made for this change, which occurs in fixing a print, it is of course "under-exposed" or "under-printed." When, on the other hand, the exposure is carried too far, the reduced organic compound of silver presents a metallic lustre, or bronzed appearance, and the details in the shadows are obliterated, and buried beneath a crust which is not easily removed in the fixing bath.

In printing by development upon chloride paper, when the print is under-exposed, the details in the lights cannot be brought out until the development has been carried so far as either to stain the paper all over, or bury the details in the shadows. When the print

is over-exposed, the details in the lights come out so rapidly in the [illegible] and darken so quickly, that the development has to be arrested before the blacks have time to acquire sufficient depth and vigour. The picture is therefore red and feeble, and the lights and shadows do not exhibit sufficient contrast.

It will be observed that in printing upon chloride paper by direct light, the longer the exposure the darker the picture becomes, *up to a certain point*, and then the reduced material afterwards assumes a metallic appearance. So also in development printing upon chloride paper, the longer the exposure and the longer the development the darker the blacks become, *up to a certain point*, and then, as in the other case, they assume a metallic appearance. By carrying the process too far, the same effect happens in both cases. And not only so, but this effect happens in many other photographic processes with metallic salts. Excessive exposure produces an amount of reduction which defeats its object by exhibiting the metallic or solarized appearance in the case of a positive print, or, in the case of a negative, that metallic condition of the reduced salt which interferes with its property of becoming a centre of attraction for the matter which should accumulate upon it from the developer.

In the daguerreotype process over-exposure produces in the iodized surface an effect which is shown by the solarized part looking blue, or sometimes quite metallic. In an over-exposed collodion positive a very similar effect of blueness is produced, which shows the analogy existing between the processes.

It appears, therefore, that by over-exposure not only is more material reduced, but the reduction of the atoms which are first acted on by light is carried to such a stage that they look metallic instead of black in positive prints; while in negatives they cease to become fit centres of attraction for the production of a picture by a developing or intensifying process.

Fading. It is unfortunately by no means an uncommon thing for photographs to become altered by time, even when preserved with the utmost care. In the case of daguerreotypes, or collodion positives or negatives, or negatives upon paper, this misfortune is, however, comparatively rare; but in the case of paper positives which have been printed by direct exposure to light, and fixed and toned with hypo-baths, fading may unfortunately be said to be the rule, and permanence the exception.

Experience has sufficiently proved that the black material of a developed argentine photograph on glass or paper is tolerably per-

manent when the fixing agent (hyposulphite of soda or cyanide of potassium) is removed by copious and thorough washing in water many times renewed, and when they are protected from sulphurous and oxidising fumes. The same may be said of the thin white metallic precipitate which forms the lights of a collodion positive. It is also necessary, in the case of a collodion positive or negative, to varnish the film, for if this be not done, the pyroxyline is liable to be decomposed, and give off an oxide of nitrogen which destroys the image.

The most serious cases of fading are those which arise in positives on paper printed directly in the light. But even here, when the predisposing causes have been ascertained and carefully avoided, fading can to a great extent be prevented. Experience has shown that photographs fade mainly from the action of sulphur on the argentine compound which forms the image. By the old method of toning and fixing prints in *acid* hyposulphite of soda, or hyposulphite containing sulphur, free or in a loose state of combination, sulphuret of silver was formed in the image, and probably also free sulphur deposited in the interstices of the paper, which after a time, especially in a damp atmosphere, attacked the picture, converting the silver when thinnest into yellow sulphuret and into a blacker form of sulphuret in the deep shadows. No amount of washing will remove this compound, nor the sulphur which the paper may contain; and therefore photographs so treated *must*, sooner or later, fade.

The more modern method of toning photographic prints after thorough washing, in an alkaline solution of chloride of gold, and then fixing them in a slightly alkaline solution of hyposulphite of soda, is not open to this objection; because there is no acid nor free nitrate of silver present to decompose the hyposulphite, which, being very soluble in water, can easily be removed by long and careful washing. There seems, therefore, good reason to suppose that, when photographic prints are thus treated conscientiously and carefully by the operator, they will not fade unless exposed to sulphuretting fumes applied intentionally or derived from the atmosphere.

The fading of photographs is often hastened by the nature of the paste used in mounting them, which is apt to become acid, and thus decompose any trace of hyposulphite which the print may contain. The best of all pastes for mounting is gelatine. Starch and gum arabic, both of which are frequently used, turn acid after a time, and the former, when the picture is kept in a damp place, generates the starch fungus, which is equally injurious.

Photographic mounting-boards often contain a considerable quantity of hyposulphite of soda, used as an antichlor by the paper-makers and not carefully removed. This salt is a valuable agent in its proper place, but, when a *finished* silver print is mounted on any material containing it, the picture must very soon fade from decomposition of this very unstable hyposulphite.

In every case, the fading of photographic prints can be traced to *sulphur*, for which silver has a powerful affinity. The object of every one should therefore be to guard them from its influence by all means in his power.

Fahrenheit's Thermometer. (Greek, θέρμη, heat, μετρον, a measure.) In this thermometer the freezing point of water, or temperature of melting snow, is marked $+32°$, and the boiling point of water, in a thin clean metallic vessel, at an atmospheric pressure of 30 inches, $+212°$. The space, therefore, between the freezing and boiling points of water is divided into 180°. In the Centigrade thermometer this space is divided into 100°, the freezing point being 0 and the boiling point 100°. There is a table at the end in which Fahrenheit's thermometer and the Centigrade are placed side by side, and the scales compared.

Fermentation. This is a peculiar metamorphosis brought about in solutions of certain organic substances, such as sugar, by the introduction of a decomposing azotised body, called a "ferment."

Ferrogelatine Developer. This term is used to designate a new and very powerful developing agent, recently discovered by Mr. M. Carey Lea, of Philadelphia, U.S. Plain acidulated protosulphate of iron solution, it is well known, will, in very few instances, develop an image of full printing density by the first application. It therefore becomes necessary to reinforce the negative by intensifying solutions of either pyrogallic acid or protosulphate of iron mixed with a little nitrate of silver. To obviate this inconvenience and waste of time, Mr. Lea has hit on the happy idea of combining gelatine with the iron, so as to give sufficient density by the first developing operation. The method he proposed has found much favour in this country and in America, and is now extensively practised.

The following modification of the original formula by Mr. Lea will be found most effective, and at the same time economical.

Take half a pound of the finest Scotch or Russian glue; break it into small fragments, and allow to soak for a night in *cold* water. Mix six ounces of commercial sulphuric acid with twenty-four of

common water in a large porcelain or glass jar capable of holding at least one hundred ounces of solution. When the mixture has cooled, pour away the excess of water in which the glue has been soaking, and add the latter to the diluted sulphuric acid. In the course of twenty-four hours, more or less, the glue will be entirely dissolved by the acid, if the mixture is occasionally stirred with a glass rod. When the solution is complete, add ten more ounces of water; tie up a number of small round bundles of clean iron wire, and throw them into the solution till they rise above the surface. Then tie up a long sheaf of the same wire to be used as a stirring rod. Place the vessel in a *warm* but not *hot* place. Hydrogen will soon commence to be evolved, showing that the iron is being converted into the protosulphate. This action will go on briskly for a few days, but if it happens to be violent remove the jar to a colder place. After a few days add ten more ounces of water, and stir well. Continue adding water or more wire as required, till the whole bulk of solution reaches eighty ounces. The operation is complete, when no more hydrogen is evolved, or when a *scum* ceases to rise to the surface.

The solution should now be filtered through common filtering paper into stock bottles, and well corked up. But previous to filtering, it is a wise precaution to dissolve in the solution half an ounce of acetate of soda, which will destroy the last traces of sulphuric acid which may remain, and which would materially interfere with the proper action of the developer. The solution so prepared will keep well for at least twelve months, without throwing down much sediment. Should a sediment be thrown down, it only shows that the glue was impure and, so far, the solution weakened. No other bad effects follow.

To use the ferrogelatine developer, make a solution of *plain* protosulphate of iron of any desired strength, and for every ten fluid ounces add one of the ferrogelatine. No acid is required, but in very hot weather it may be necessary to add more than one ounce of the gelatine solution to prevent fogging. The image comes out more slowly than is usual with plain acidulated protosulphate, but the action of development is more uniform, and may be continued till almost any density can be secured. The chief thing to be avoided is carrying it too far, and thus getting hard negatives.

Another modification of the gelatine developer, which answers very well, was suggested by a clergyman in England. It consists in soaking for several hours from sixty to ninety grains of gelatine in about six ounces of cold water, then adding two ounces of glacial acetic acid, and dissolving the gelatine by means of a gentle heat.

A quantity of this, proportioned to the temperature and other circumstances, is to be added to the plain protosulphate of iron solution instead of acetic acid. In most instances this developer gives quite sufficient density by the first application.

Ferrotype. A name given by Mr. Hunt to a process in which an argentine photograph is developed with proto-sulphate of iron. The term is no longer in use in this country, but sometimes in America.

Filtration. This is a process for separating a liquid from the insoluble matter which it may contain. The liquid to be filtered is made to pass through a porous substance, such as unsized paper, porous earthenware, cloth, sand, &c. When common blotting-paper is used, it should first be washed with dilute muriatic acid, in order to remove some lime and iron which it generally contains. Filter papers are generally cut round, and the sides folded in puckers like a fan. They are then placed in a glass funnel, the diameter of which should be about three-fourths of its height, measured from the neck. The liquid should be poured into the funnel very gently along a glass rod. A filter covered with sediment may be conveniently washed by squirting water against it from a small syringe. Linen or calico should be used for filtering weak alkaline liquids, and flannel or felt-stuff for weak acid ones. These filter bags are made like a fool's cap, and have a wooden hoop at the top. Cotton wool, put into the neck of a glass funnel, makes a good filter for many purposes. Strong acids and alkalies should be filtered through a layer of pounded glass, quartz, clean sand, or bruised charcoal.

Sometimes the liquid is made to *ascend* in the filter by hydrostatic pressure. This is often a very good plan.

Volatile liquids, such as ether, collodion, benzole, &c., should be filtered under an air-tight vessel, or in a suitable filter sold for the purpose.

Fixing. By this term is meant, in the daguerreotype process, the fixation of the image to the plate by means of a boiling hot solution of *sel d'or*. The image can then no longer be rubbed off by finger. In the ordinary collodion and paper processes the term "fixing" is generally used to denote the removal of the sensitive material from the tablet, when the picture itself is in other respects completed.

Flame. The combustion of an inflammable vapour mixed with air, or, according to some, "luminous gaseous matter." The lumi-

nosity of a flame depends chiefly on the presence of particles of solid matter. For instance, the flame of burning hydrogen is intensely hot and very feebly luminous; but if a little lime be dusted into it, the particles become intensely luminous. In general it appears that the greater the *heat* of a flame the less the *light*, and conversely. If the top of the glass chimney of an oil lamp be contracted, there is less escape of smoke, more combustion of solid matter, and the light is increased with a diminution of the oil consumed. In the case of the flame of a candle or spirit lamp, combustion only takes place at the outer surface of the flame and not in the centre; this may be proved by inserting a tube into the hollow of the flame, when the inflammable vapour will pass up it, and may be lighted at its other extremity. In the Argand lamp the wick is cylindrical, and the inside of the flame is supplied with air.

Flame can only exist at a very high temperature. If a piece of wire gauze be laid across a flame, it conducts away some of the heat, and the combustible vapour, cooled by passing through the gauze, passes off on the upper side without flame. This is the principle on which Davy's safety lamp is constructed.

Flare. Stray light falling upon the sensitive plate during its exposure in the camera.

When certain forms of double or triple compound lenses are used, and the camera is turned towards a strong light, such as the sky, a circular spot of flare is sometimes seen in the centre of the ground glass. The cause of this has been a great puzzle to opticians and photographers. Some persons have supposed that it is the image of the round central stop formed by the back lens; but that idea is absurd, because, if a bright object were placed so much nearer to the lens than its focal length, no real image of it *could* be formed, for the rays would still be divergent, and would cover the entire screen. Others have supposed that the round spot of light is produced by rays which have suffered internal reflexion at the front lens; but that supposition is open to some fatal objections. The probability is that it is really produced by reflected light from the bright edges of the lenses, since, when these are blackened and properly covered with an annulus of metal, the flare spot disappears.

No one should purchase a lens without first submitting it to the following test:—Mount it in the camera, and point the instrument towards the sky. Throw a black cloth over your head and shoulders, and look into the inside of the camera from behind. If you then see a ring of light round the circumference of the lens, reject it, for it will never give a clear *picture of* a view in which any portion of the

sky is introduced. The cheap French portrait lenses are generally subject to the above defect. It never exists in the double and triple lenses manufactured by the best English opticians.

Flint Glass. The composition of a good flint glass, sp. gr. 3·2, is as follows:—120 parts of fine clear white sand, 40 purified pearl-ash, 35 litharge (red oxide of lead, or "minium"), 13 nitre, and a small quantity of black oxide of manganese.

Flint glass is distinguished from crown glass by the absence of colour, and its higher refractive power. The lead, which is absent in crown glass, renders the flint glass more fusible, and increases its refractive power, giving it great brilliancy when cut; but it has some disadvantages, for glass containing lead is softer and more easily scratched; and it is difficult to obtain it of equal density throughout, and free from wavy marks or striæ.

When borate of lead is added to glass, the density and refractive power are raised to the maximum at present known. *See* "Glass."

Flowers, Coloured Juices of. Some of the coloured juices of flowers have been shown by Sir John Herschel and M. Chevreul to be sensitive to light, but none of them have yet been employed in Photography. The reader is referred to Sir John Herschel's memoir on this subject in the "Philosophical Transactions," Part 2, for 1842, for further information.

Fluorescence. This term has been introduced by Professor Stokes to denote a remarkable property possessed by certain substances with respect to light, and it has been adopted from the fact that fluor spar exhibits the phenomenon in a marked degree.

Suppose a trough, the sides and ends of which are made of plate glass, to be filled with a solution of sulphate of quinine. A ray of sunshine is admitted through a small hole in a shutter, and passed through a prism so as to be decomposed into rays of the prismatic colours. The trough, with its solution, is then placed so as to receive and transmit the solar spectrum. On looking through the ends of the trough, the luminous and least refrangible rays are seen to be transmitted, while the extreme violet rays are absorbed, and seen to penetrate only to a certain depth in the liquid; and in addition to this, rays beyond the violet, which were before invisible, are now rendered visible, and appear of a celestial blue colour, penetrating to a certain depth, and then disappearing.

If a piece of sensitive photographic paper be placed so as to receive he spectrum transmitted through the fluid, it is found that the usual arkening at and beyond the violet end of it is wanting.

A block of yellow uranium glass possesses a similar property to the solution of sulphate of quinine. So do æsculine and other substances.

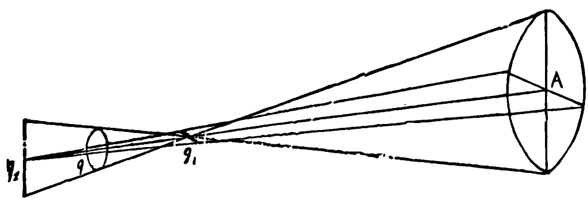
For further particulars of this curious phenomenon, the reader is referred to Mr. Stokes's original paper in the "Philosophical Transactions" for the year 1852.

It has been said that fluorescent bodies have the property not only of rendering the invisible rays visible, but of imparting chemical action to the luminous rays. This assertion must, however, be received with caution, and will probably turn out to be erroneous.

Mr. Stokes is of opinion that "the phenomena of internal dispersion oppose fresh difficulties to the supposition of a difference of nature in luminous, chemical, and phosphorogenic rays, but are perfectly conformable to the supposition that the production of light, of chemical changes, and of phosphoric excitement, are merely different effects of the same cause."

Fluorine. F=7. This is a hypothetical elementary body, which has not yet been isolated. Some of its compounds are well known.

Focal Lines. When a small oblique pencil is reflected or refracted at a spherical surface, or refracted at a plane surface, the reflected or refracted pencil has not a "geometrical focus," or "least circle of aberration," but all the rays composing it pass through two straight lines (or elongated figures of 8), situated in planes at right angles to each other, and called respectively "primary" and "secondary focal lines."



For instance, suppose the circle at A, situated in a plane perpendicular to that of the paper, to be the base of a small pencil which has suffered oblique reflection or refraction. Then all the rays composing this pencil will first pass through the "primary focal line" q_1, which is perpendicular to the plane of the paper, and afterwards through the "secondary focal line" q_2, which is *in* the plane of the paper. The reason of this it would be out of place to discuss

in the present work; the fact must be taken for granted; the demonstration of it will be found in Coddington's "Treatise on Optics." If a section be made of the curious solid formed by the pencil between the focal lines, at a certain point *q* between them, that section will be a circle, and it is the nearest approach that the pencil can have to a focus. This circle is called the "circle of least confusion."

The proportions of the figure are, of necessity, greatly exaggerated. The distance between the focal lines is in general very small compared with the distance of either of them from A; but the distance q_1 q_2, and also the diameter of the circle of least confusion, increase as the obliquity of the incident pencil increases.

Focal Range. In every lens there is, corresponding to a given apertal ratio (that is, the ratio of the diameter of the stop to the focal length), a certain distance of a near object from it, between which and infinity all objects are in equally good focus. For instance, in a single view lens of 6 inch focus, with a ¼in. stop (apertal ratio one-twenty-fourth), all objects situated at distances lying between 20 feet from the lens and an infinite distance from it (a fixed star, for instance) are in equally good focus. Twenty feet is therefore called the "focal range" of the lens when this stop is used. The focal range is consequently the distance of the nearest object, which will be in good focus when the ground glass is adjusted for an extremely distant object. In the same lens the focal range will depend upon the size of the diaphragm used, while in different lenses having the same apertal ratio the focal ranges will be greater as the focal length of the lens is increased.

The terms "apertal ratio" and "focal range" have not come into general use, but it is very desirable that they should, in order to prevent ambiguity and circumlocution when treating of the properties of photographic lenses. "Focal range" is a good term, because it expresses the range within which it is necessary to adjust the focus of the lens to objects at different distances from it—in other words, the range within which focusing becomes necessary.

Focimeter. This is an instrument suggested by M. Claudet for finding the chemical focus of a lens which has not been properly achromatized.

A number of boards are arranged in a spiral about a horizontal axis, at different distances, and each board is painted white, and inscribed with a black letter. These boards are so placed as to be all visible together from the lens. If, when one of them is in exact

visual focus, another is found to come out more distinctly in the photograph, it is evident that the visual and chemical foci do not coincide, and the lens should be rejected as unfit for use.

Focus. A focus is either "real" or "virtual." A "real" focus is a point through which an assemblage of rays actually passes; a "virtual" focus one through which their *directions*, if produced forwards or backwards, *would* pass.

A lens is said to have "positive focus" when the focus of a parallel pencil refracted through it is on the *same* side of it as the origin of light. A *concave* lens has therefore *positive* focal length.

A lens is said to have "negative focus" when the focus of a parallel pencil refracted through it is on the *opposite* side of it to the origin of light. A *convex* lens has therefore *negative* focal length.

In the former case the focus of the pencil is "virtual," in the latter case "real."

The *principal* focus of a lens, whether positive or negative, is the focus of a pencil of *parallel* rays after refraction through it.

The "least circle of aberration" is the nearest approach to a perfect focus which a *direct* pencil can have; and the "circle of least confusion" the nearest approach to focus possessed by an *oblique* pencil. It is incorrect to speak of the *aberration* of an oblique pencil.

Focusing Glass. This is a magnifier used for the purpose of enlarging the image on the ground glass, and enabling the operator to get it into better focus. A good form is that of the Ramsden's eye-piece of a telescope, which consists of two equal single plano-convex lenses, placed with their plane sides outwards, and at a distance apart equal to two-thirds of the focal length of either. When in use, the image on the ground glass must be in the principal focus (or thereabouts) of the eye-piece or focusing magnifier. It must be remembered that Ramsden's eye-piece is not achromatic. A common short focussed single stereo-combination answers capitally.

Fog; Fogging. When a precipitate is thrown down over the entire plate by the action of the developer, so as to obscure, in the deepest shadows, the transparency of the glass when looked through, that precipitate is called "fog," and the picture is said to be "fogged." The principal causes of fog are—alkalinity of the nitrate of silver bath or neutrality of the same when a bromoiodized collodion is used, over acidity of the bath, diffused light either in the

camera or dark room, dirty plates, and sometimes from the lens itself. An alkaline nitrate bath and a very acid one seem to have very similar properties as respects "fogging." It is only when the acid and alkaline elements are properly balanced so as to suit the nature of the collodion that a good photographic negative can be obtained. No collodion can be worked in an alkaline bath, but a pure simply iodised collodion, when it turns to a pale sherry colour, can be used with the best effect in an absolutely neutral nitrate solution. Collodion, paper, or any other sensitive medium which contains besides the iodide an organic compound, must always be sensitized in an acid bath, to prevent fogging.

Formic Acid. $HO, C_2 HO_3 = 46$. This acid was first discovered by Fisher in the red ant (*Formica rufa*); hence its name.

Formic acid and the alkaline formiates are reducing agents, and reduce the oxides of the noble metals, the acid being oxidized into carbonic acid.

Formic acid was originally obtained by distilling the ants with water; but the principal processes now employed for producing it are as follows:—

1st. 10 parts of starch, 37 of binoxide of manganese, 30 of water, and 30 of sulphuric acid are distilled in a retort (the capacity of which should be at least ten times that of the mixture), until 38 parts have passed over.

2nd. Concentrated formiate of soda and sulphuric acid distilled together yield very strong fuming formic acid, containing only 1 atom of water, but the sulphuric acid must not be in excess.

Formic acid is a colourless and slightly fuming liquid of a pungent odour, and acting as a caustic upon the skin. It freezes at 30°, and its sp. gr. at 60° is 1·235. It boils at 210°, yielding an inflammable vapour, which burns with a blue flame.

While formic acid acts as a reducing agent, it also acts as a restrainer to the ordinary developer. It was, therefore, recommended long ago by some photographers, and more recently by M. Claudet, to conjoin it with pyrogallic acid. By this method of development it has been stated that the time of exposure may be considerably shortened. This assertion has not been verified.

Fothergill Process. This is a dry collodion process introduced by Mr. Fothergill some years ago, and so much improved by him in the year 1864 as to be now considered one of the best known instantaneous dry processes. His original method consisted in applying albumen to the sensitive film, as a preservative, and then

washing it all off again. The plates, developed with the old-fashioned acid developer, were very insensitive, but yielded fine results. His new process is a great improvement on the old one, and will be found minutely described in a treatise on "Instantaneous Dry Collodion Processes" (Low and Marston). The following is an outline of it :—

The collodion must contain not less than 2 grains of bromide of cadmium to the ounce, to which may be added 4 grains of iodide of cadmium. After the plate has been excited in the usual 30-grain nitrate bath, it is well washed, and a preservative is poured over it, which is made in the following way :—

Beat up to a stiff froth some whites of eggs and let the clear liquid settle. On the next day decant it; and to every ounce add 20 minims of ammonia. This is the stock solution. When required for use, take 30 minims of a 30-grain solution of nitrate of silver, and add to it 50 minims of ammonia. Mix them well together, and add this to one ounce of the albumen from the stock bottle. This is the preservative. It must be used immediately, for it will not keep. Pour it over the plate in the usual way, let it remain on a minute, then wash it all off, and put away the plate to dry.

Give the same exposure as for a wet collodion plate, and develop the image, either by the usual alkaline method, or with a simple solution of pyrogallic acid without the addition of soda or ammonia. In the latter case a bolder picture is produced, but not quite so full of detail. Wash off the developer, rinse the plate with water acidified with acetic acid, and intensify the feeble image in the usual way. Fix with hyposulphite of soda, not with cyanide of potassium.

In this process the film adheres tightly to the glass, but is rather liable to blister if the development is too prolonged. The sensitive film is in an alkaline condition when exposed, and contains a trace of ammoniacal oxide of silver. The plate is not therefore likely to keep well. The negatives are of a yellowish non-actinic colour, and very delicate in detail.

Fraunhofer's Lines in the Spectrum. *See* "Spectrum."

Freezing Mixtures. *See* "Table of Freezing Mixtures" at the end.

French Cement. Gum-water thickened with powdered starch. A little lemon juice is sometimes added. It keeps good for a long time.

French Polish. Dissolve with a gentle heat 22 ounces of shellac in 80 ounces of rectified alcohol.

French polish is mixed with a few drops of oil at the time of application, and applied to the wood with a ball of cotton-wool; it is then rubbed briskly in the direction of the fibre, and finished, after drying by friction, with tripoli and oil.

Fuller's Earth. This is a greenish or yellowish gray powder found in different parts of England. It is used for removing grease spots, and also for decolourizing old nitrate baths, which is effected by filtering them through it. It is composed of silica, 5·3 parts; alumina, 10; red oxide of iron, 9·75; magnesia, 1·25; lime, 5, and a trace of potash.

Fumigating Process. This consists in subjecting sensitized albumen-paper to the fumes of ammonia, whereby the paper is said to become much more sensitive to light. The process is extensively practised in America, but has not received much attention in this country, experience being opposed to its utility. It probably requires the paper to be prepared differently from ours before all the advantages claimed for the process can be realized.

The sheet, when sensitized on the ordinary nitrate bath, is attached, albumen-side downwards, to the lid of a close box, in the bottom of which is placed a porcelain dish, containing a drachm or more of strong liquid ammonia. The lid is then closed for about ten minutes, by which time the ammoniacal fumes will have filled the box, and come in contact with the excess of nitrate of silver on the surface of the paper, converting it into oxide of silver and nitrate of ammonia. The paper is then taken out, and, as soon as the excess of ammonia has evaporated, is fit for printing.

Fusel Oil, or Hydrated Oxide of Amyl. The oil of potato-spirit. This impurity exists more or less in all spirits distilled from potatoes, sugar, or corn. It is of a peculiarly suffocating odour and intensely acrid taste, and mixes with alcohol and ether in all proportions, but not with water.

It acts injuriously on the nitrate bath when it happens to be present in solvents of pyroxyline. When, however, they are properly rectified, there is little chance of its being present in hurtful quantity.

Fusible Metal. This metal fuses at the temperature of boiling water. It is composed of:—

Bismuth	8 parts.
Lead	5 „
Tin	3 „

and sometimes 1 part of mercury is added.

Gall. Ox-gall. The bile of the ox. Bile is a secretion which is separated from the venous blood in the liver. It is supposed to be a saponaceous compound in which an organic acid is combined with soda. Ox-gall is of a dingy green colour, transparent, and viscid; having a peculiar odour and a nauseously bitter taste. It has a slightly alkaline reaction, and mixes in all proportions with water.

Ox-gall may be clarified in the following manner:—Take the gall of newly killed oxen, and let it settle for 12 or 15 hours in a basin. Pour the supernatant liquor off the sediment into an evaporating dish, and boil it until it is somewhat thick. Then spread it upon a dish, and put it before a fire until it becomes nearly dry. In this state it may be kept for years in jelly-pots covered with paper. When required for use, a piece of it the size of a pea is to be dissolved in a table-spoonful of water.

Ox-gall may be rendered perfectly colourless in the following manner:—To a pint of gall, boiled and skimmed, add one ounce of fine powdered alum, and leave the mixture on the fire till the alum is dissolved. When cold, pour it into a bottle, and cork it loosely. Next, treat another pint of gall in exactly the same way, only substituting salt for alum. In about three months these preparations will deposit a thick sediment. Then decant the fluid portion of each, and mix them. A precipitate is immediately formed which takes down the colouring matter, and the supernatant liquid may then be filtered, and is as transparent and colourless as water.

Clarified ox-gall combines readily with colouring matters or pigments, and gives them solidity, either by being mixed with them, or passed over them upon paper. It increases the brilliancy and durability of ultramarine, carmine, green, and in general of all delicate colours, while it contributes to make them spread more evenly upon paper, ivory, &c. When mixed with gum arabic, it thickens the colours without making them glisten, and prevents the gum from cracking, and fixes the colours so well that others may be applied over them. Along with lamp-black and gum it forms a good imitation of Indian ink. When a coat of ox-gall is put upon drawings made with black lead, or crayons, the lines can no longer be effaced, but may be painted over with a variety of colours previously mixed with the same ox-gall. Miniature painters find great advantage in using it. When passed over ivory it removes the unctuous matter from its surface; and when ground with the colours makes them spread with the greatest ease, and renders them fast. It serves also for transparencies, being first passed over the oiled, or waxed, or varnished paper, and allowed to dry. The colours

mixed with the gall are then applied, and cannot afterwards be removed by any means. It is useful to the photographer in blackening the skies of waxed-paper negatives; for when mixed with the Indian ink it causes it to flow more readily on the greasy surface of the wax.

Ox-gall is also used for taking out spots of grease and oil.

Gallic Acid. $3\,HO, C_{14}\,H_3\,O_7 + 2\,HO = 188$. This acid was discovered by Scheele in 1786. It may be obtained as follows:—

Powdered galls are mixed with water, and the paste exposed for some weeks to the air, at a temperature of from 70° to 75°, adding water occasionally to prevent the paste from drying. The powder swells and becomes mouldy; and when the magma is exposed to pressure, a quantity of coloured liquor may be squeezed out. The residue or cake is then boiled in water, and the solution filtered while hot. On cooling, it deposits crystals of gallic acid, which may be purified by re-dissolving and boiling with a little animal charcoal. The filtered solution then deposits the gallic acid in white silky crystals. These are of a slightly sour and astringent taste, soluble in 100 parts of cold, and three parts of boiling water; readily soluble in alcohol, and sparingly soluble in ether.

Gallic acid is obtained in the above process by the oxidation of the tannic acid contained in the galls, by exposure to air. It is a feeble acid, and scarcely reddens litmus paper. It is a most important agent in Photography, from its deoxidizing property. The products of its oxidation have not yet been thoroughly investigated.

The aqueous solution of gallic acid becomes mouldy and discoloured by keeping.

Gallic acid gives no precipitate with gelatine.

Galls. The gall-nut is an excrescence which forms upon the branches and shoots of the *Quercus infectoria*, being produced by the puncture of the female of the *Cynips gallæ tinctoriæ*, or gall wasp, which insect deposits its ovum in the puncture, and occasions the excrescence or gall, within which the larva is developed, and when the insect is perfect it eats its way out. The best galls, known in commerce as black or blue galls, are gathered before the insect has escaped; the white galls are those from which the insect has departed, and are consequently perforated with a small circular hole. They are of a brownish or dingy yellow colour, but less heavy and astringent than the others. Gall-nuts are chiefly imported from Turkey, and have long been used as a source of black dye, and in the manufacture of writing ink. They contain a larger quantity of tannic acid than any other known vegetable product.

The insect which produces the gall-nut is about a quarter of an inch in length, and, when the wings are expanded, nearly an inch in breadth. It is to be found chiefly in Asia Minor and Turkey, and is of a dirty yellowish-brown colour.

The *Quercus infectoria*, or gall oak, is found chiefly in Asia Minor.

Infusion of galls is a chemical antidote in cases of poisoning by opium or nux vomica.

Gamboge. A gum resin, concreted from the milky juice which exudes from the *Gambogia gutta* and *Guttæfera vera*, trees native in Ceylon and Siam. It consists of about 85 parts of a red resin soluble in alcohol, and 15 parts of gum. It is a valuable pigment, and may be used for painting out the skies of negatives.

Gelatine. $C_{13} H_{10} O_5 N_2$. This substance is produced by the action of hot water on the membraneous tissues of animals. To obtain it, such substances as clippings of hides, hoofs, horns, calves' feet, cow's heel, sheeps' trotters, pigs' pettitoes, certain membranes, &c., are cleansed in cold water and then boiled. The solution so obtained is freed from fat, and any deposit, by skimming and straining, and allowed to form a jelly on cooling. This is called *size*, and when cut into slices and dried is called *glue*.

The purest form of gelatine is *isinglass*, which is obtained in Russia from the air-bladder and sound of a species of sturgeon.

Size is sometimes obtained from the waste of vellum, parchment, and some kinds of white leather, and also from bones. It may be rendered inodorous, tasteless, and colourless by the careful application of sulphurous acid. It is then called *patent gelatine, gremetine*, &c.

Gelatine gradually softens and swells in cold water, but does not dissolve without heat. It absorbs three or four times its weight of cold water. One part of isinglass dissolved in 100 of hot water gelatinizes on cooling, but in 150 parts remains liquid; the effect, however, varies with the temperature.

When a solution of gelatine is repeatedly boiled and cooled, it loses its power of gelatinizing on cooling, and remains soluble and deliquescent. In this state it has been called by photographers *metagelatine*.

Gelatine is insoluble in absolute alcohol and ether, and also in fixed and volatile oils. When alcohol is added to a warm and strong aqueous solution of gelatine, the gelatine separates as a white viscid substance; and if a drop of the same solution of gelatine be

added to alcohol, ether, or collodion, the gelatine immediately rolls itself up into a white ball, and sinks to the bottom of the bottle.

Gelatine is soluble in all the dilute acids, differing essentially in this respect from albumen. Of these, the acetic solution only gelatinizes on evaporation.

The dilute caustic alkalis, and ammonia, do not prevent the gelatinization of gelatine, but often throw down a portion of phosphate of lime. When gelatine is dissolved in a cold dilute solution of caustic potash, and exactly neutralized with acetic acid, the evaporated liquor does not gelatinize on cooling; it leaves a residue of altered gelatine combined with acetate of potass, which is soluble in alcohol.

Tannin precipitates gelatine from its solution as a dense white curdy precipitate, called tanno-gelatine. It is on this principle that leather is produced by the long soaking of hides in infusion of oak bark. Tannin is a very delicate test of gelatine, for when added to a solution of 1 part of gelatine in 5000 of water a cloudiness is produced. Sulphate of platina produces the same effect, and is the better test of the two, as it does not act in a similar way on albumen as tannin does. A mixture of salt and alum also forms a white precipitate with gelatine.

Gelatine is capable of combining with some of the metallic oxides; for instance, with the oxides of iron, chromium, lead, tin, mercury, silver, gold, and platinum, its combination with silver and gold being effected by means of light, for it does not readily alter the colour of their solutions if kept in the dark.

Gelatine has many important uses in Photography, and enters largely into the sizing of English photographic papers.

Geometrical Focus. The focus of an infinitely small direct pencil, after reflection or refraction.

German Silver. This is an alloy of nickel. The common sort is composed of copper 8, nickel 2, zinc 3½. A better sort has one part more of nickel; and the best sort, called *electrum*, has two parts more of nickel. This last has a tinge of blue, like very highly polished silver, and tarnishes less easily than silver. Objects may be electroplated with nickel in the same way as with copper; using either the sulphate or chloride of nickel. German silver is superior to brass for optical instruments.

Gilding Dissolvent. This liquid is used for obliterating the images which have been fixed by *sel d'or* upon daguerreotype plates. *Its exact composition* has not been published, but it no doubt con-

tains nitro-hydrochloric acid, disguised in some way. A mixture of salt and dilute nitric acid, or of nitre and dilute hydrochloric acid, will answer the purpose equally well.

Glacial Acetic Acid. *See* "Acetic Acid."

Glass. Glass is a mixture of various insoluble silicates with excess of silica, and devoid of crystalline structure. The alkaline silicates, when in a state of fusion, have the power of dissolving a large quantity of silica.

There are two principal varieties of glass. The first comprises crown and plate glass, and is composed principally of silica, potass, and lime; the second, called flint glass, contains, in addition, silicate of lead; the lead promoting fusibility, and increasing the density, lustre, and refractive power.

The principle of the glass manufacture is very simple. Silica, in the shape of fine sand, is heated with carbonate of potass or soda, and slaked lime, or oxide of lead. At a high temperature, fusion and combination occur, and carbonic acid is expelled. When the melted mass has become clear and free from air-bubbles, it is left to cool slowly, until it assumes the peculiar tenacious condition suitable for working.

Crown and plate glass have a greenish colour; flint glass is colourless, and has a higher refractive index. Plate glass is cast upon a flat metal table, rolled, and, after very careful annealings, ground true and polished by machinery. (*See* "Plate Glass.") The large circular tables of crown glass are made by the glass blower. A long iron tube, called the blow-pipe, with a wooden mouthpiece, has its end dipped into the tenacious, soft, semi-fused glass in the glass pot. The lump of glass thus removed is then blown into a flask. An iron rod, called a pontil, is then dipped into the glass pot, and applied to the bottom of the flask, so as to form a handle to it. The blow-pipe is then detached from the neck of the flask, which is again heated in the furnace, and then suddenly turned with great rapidity, so that the centrifugal force causes it to assume the shape of a flat disc. This done, it is removed from the pontil, leaving a great knob or bull's eye of glass in the centre of the sheet, and put into the annealing oven, where it is allowed to cool slowly. Unless glass is *annealed*, or allowed to cool very slowly in this way, it becomes exceedingly brittle.

Tables of crown glass made in this way exhibit an exceedingly fine polished surface, although not strictly flat, like that of plate glass. Sheet glass is made by blowing a hollow cylinder, then cut-

ting it lengthwise with a red-hot iron, and spreading it open upon a flat table.

Glass is coloured by the addition of various metallic oxides. Oxide of cobalt gives deep blue; oxide of manganese, amethyst or black; sub-oxide of copper, ruby-red; black oxide of copper, green; the oxides of iron, dull green or brown; oxide of uranium, yellow; oxide of silver, yellow; purple of cassius, a ruby tint; oxide of antimony, yellow; oxide of chromium, fine reds and greens.

Opaque white glass, called white enamel, is made by adding oxide of tin.

The colouring oxide is either added to the glass in the glass pot, or applied afterwards to the surface, and burnt in.

Kane gives the following tabular view of the composition of several kinds of glass (Elem. Chem., 720):—

Constituents.	Hard White Glass. 1	2	Crown Glass. 3	4	Bottle Glass. 5	6	Crystal. 7	Flint Glass. 8	9
Silica	71·7	69·2	62·8	69·2	60·4	53·5	59·2	51·9	42·5
Potash	12·7	15·8	22·1	8·	3·2	5·5	9·	13·8	11·7
Soda	2·5	3·		3·					
Lime	10·3	7·6	12·5	13·	20·7	29·2			·5
Alumina	·4	1·2		3·6	10·4	6·			1·8
Magnesia		2·	2·6	·6	·6				
Oxide of Iron	·3	·5		1·6	3·8	5·8	·4		
——— Manganese	·2						1·		
——— Lead							8·2	33·8	43·5
	98·1	99·3	100·	99·	99·1	100·	97·8	99·	100·

No. 1 is the difficultly fusible Bohemian glass; No. 2, ordinary Bohemian glass; No. 3, English, and No. 4, German glass; Nos. 5 and 6, French glass; Nos. 7 and 8, English; No. 9, the celebrated optical glass of M. Guinaud, late of Brennets, near Geneva.

All common glass, when reduced to fine powder, is more or less acted on by boiling water, which separates the alkali; glass cannot therefore be considered as insoluble in water. If finely-powdered glass be laid upon a piece of reddened litmus paper and moistened with water, the moisture restores the blue colour of the paper by dissolving out the alkali in the glass. The power of glass to resist the action of water, alkalis, acids, air, and light, is in general greater the higher the temperature employed in its manufacture, the smaller the proportion of its fluxes, and the more exact the chemical ratios of its constituents. Most crystal glass is affected by having water in it for a considerable time; but crown glass, being poorer

in alkali, and containing no lead, resists that action much longer, and is better adapted for chemical purposes.

Air and light act upon glass, probably by their oxidising property. Bluish and greenish coloured glasses become colourless by exposure, in consequence of the peroxidation of the iron they contain. Glass containing manganese becomes purple-red by the peroxidation of that metal from the same cause. Flint glass, which contains lead, is acted on by sulphuretted hydrogen, and the surface rendered opaque and iridescent. Achromatic lenses should, therefore, be carefully preserved from the action of sulphur.

Charcoal colours glass of a yellow or brownish tint; so that it is impossible to make glass in furnaces which smoke.

The discovery of glass is said by Pliny to be due to the following accident:—A merchant ship laden with natron (soda) being driven in a gale upon the coast of Syria, at the mouth of the river Belus, the crew were compelled to cook their victuals ashore, and having placed lumps of the natron upon the sand as supports to the kettles, found to their surprise masses of transparent stone among the embers. According to Pliny and Strabo, the glass works of Sidon and Alexandria were famous in their times, and produced beautiful articles, which were cut, engraved, gilt, and stained of the most brilliant colours in imitation of gems. Some of the windows of Herculaneum appear to have been glazed.

For an account of the glass used in optical instruments *see* further particulars in the articles "Optical Glass," and "Plate Glass;" and for the method of grinding lenses, *see* "Lens."

Glass, Soluble. When silica is melted with twice its weight of carbonate of potash or soda, and the product treated with water, the greater part dissolves, yielding a solution from which acids precipitate gelatinous silica. This is the *soluble glass* mentioned by some chemical writers. Its solution has been used for rendering muslin and other cotton fabrics incombustible.

If stone or brick work be first washed over with the above solution of silicate of soda, and then with a solution of chloride of calcium, a double decomposition takes place by which common salt and silicate of lime are produced. The latter is an insoluble salt and forms a glaze on the surface to which it is applied, filling up the cavities and protecting it from the weather. It has been proposed to employ this process for architectural purposes, and it may perhaps find some uses in Photography.

Glass, Drayton's Method of Silvering. Make an edging of wax all round the glass plate. Pour into the dish thus formed a

solution of ammonio-nitrate of silver, to which a reducing agent, such as grape sugar, is added. In a short time the glass will be covered with a beautiful metallic coating of silver.

Glass Dishes and Baths. Dishes are sometimes made of plate glass for holding the nitrate bath. The bottom is formed of one piece of plate glass, and the sides of strips cemented to it with marine glue. The edges and ends of these strips should be accurately ground. To cement them together, the pieces are heated with a spirit lamp, and the glue rubbed on while still hot, and the pieces immediately applied together, and pressed into contact. It is by no means an easy operation. Solid glass dishes, but not perfectly flat, can now be obtained. Upright glass baths are also commonly used for holding the nitrate of silver solution. They are far better than any other kind of ware, for home use, though it is desirable that something equally efficacious but less fragile should be designed for the tourist.

Glass Studio. The room in which photographic portraits are taken. The best form of this important room, and the best mode of lighting it, have been made of late the subject of much discussion; and the opinions of the leading photographers, and their practice too, differ widely on these points. We can only venture humbly to point out what, in our opinion, are the leading principles to be observed in the construction of the glass room.

Sunshine should never be permitted to enter it; the camera should be placed in a long dark passage; the room should be well ventilated, and the apertures through which light enters should be provided with moveable windows which can be opened whenever the weather permits; there should be no top light over the head of the sitter; the studio should not be made a lounge for visitors, but be contrived to answer well the particular purpose for which it is required, irrespective of any other. If all these points are attended to, the room can hardly fail to be a good one, provided, of course, that it admits sufficient light for taking portraits by the processes now in use, and that the light can be directed in a proper manner upon the sitter. What that proper manner may be must always depend upon artistic considerations, and no general rule can be laid down; but the windows of the studio should be so contrived as to meet a variety of different conditions which must arise, depending on the age, sex, and physiognomy of the sitter. A photographer devoid of taste and intelligence would only succeed by a happy accident in taking an artistic portrait in the best contrived of glass

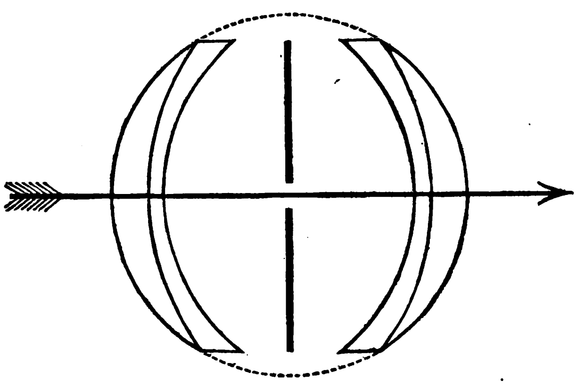
rooms; while a man possessing taste and intelligence might produce many excellent portraits at times in a very ill contrived studio.

Glazier's Putty. Whiting, or white lead, made into a paste with boiled linseed oil.

Globe Lens. A view lens introduced about seven years ago by Mr. Harrison, optician, of New York. It is extensively used in America, though not in Europe; being surpassed in width of field, defining power, and brilliancy of the image, by the new DOUBLET lens of Mr. Ross.

The globe lens appears to have been the result of an experiment made by Mr. Harrison, with the view of dispensing with the water in the panoramic lens invented by Mr. Sutton. It was found that by preserving the external globular form of the panoramic lens, but achromatizing it by means of two deep menisci, having concave lenses of flint glass cemented in contact with them, the field of the lens had no longer the same curvature as a concentric sphere, but is in fact almost flat, over a very wide extent of angle. Therefore, by sufficiently reducing the diameter of the central stop, a very good landscape lens was produced, which yielded images free from distortion, and including a very wide range of subject. The theory of the flattening of the field by this peculiar construction is given in the article on the "Deep Meniscus" (*q.v.*)

The following figure exhibits the construction of Mr. Harrison's globe lens:—



The instrument is symmetrical, and the curves are all very deep, which makes it a costly affair. The Ross doublet is not sym-

metrical, the corrections of the marginal pencils are better effected, and the curves are not so deep. It is therefore a smaller, better, and cheaper instrument than the globe. The main principle is, however, the same in both, viz., the flattening of the field by the use of deep meniscus lenses.

Glucose, or Grape Sugar. This variety of sugar is found in the juice of the grape and many other fruits, and it may also be extracted from honey. It is less sweet and less soluble in cold water than cane sugar, and does not crystallize with regular faces. In Photography it is sometimes used as a preservative for dry collodion plates; but for this purpose it is inferior to many other substances.

Glue. An impure kind of gelatine, *q.v.* There are several varieties of it in the market. Russian glue is the purest, next the Scotch, and then the English. For mounting photographs, the best Scotch or Russian glue should be used, because the other contains many impurities which might affect the stability of the image.

Glue (*liquid*). The best formula for this ambiguous substance is the following:—Powdered orange shell lac, 1 ounce by weight, alcohol, sp. gr. ·805, 2 fluidounces. Digest the mixture in a stoppered bottle in a warm place till the resin is dissolved. This forms an admirable cement for wood, &c., so strong, indeed, that the cemented material, when tested, will break elsewhere than at the joining.

Glycerine. $C_6H_8O_6 = 92$. (Gr. γλυκυς, sweet.) Glycerine is a sweet substance which may be extracted from fatty bodies and oils. In its purest form it is obtained in the following manner:—

Take equal parts of olive oil and finely ground litharge; put them into a basin with a little water, and set it on a sand bath moderately heated, continually stirring the liquid and adding fresh boiling water when necessary. In this way in a short time a soap or plaster of lead is formed. Add more water to this and remove the vessel from the fire, decant the liquor, filter it, and pass sulphuretted hydrogen through it to separate the lead; then filter again and concentrate the liquid as much as possible by evaporation without allowing it to be burned on the sand bath. Evaporate what remains under the receiver of an air pump. This is glycerine. It is a transparent liquid without colour or smell, and of a syrupy consistence. Its sp. gr. at 60° is 1·23. Water combines with it in all proportions, and alcohol dissolves it readily, but it does not mix with ether or oils.

Glycerine is a neutral substance, and exhibits no tendency to

combine either with acids or bases. It has but little action upon nitrate of silver, even in the light. Glycerine, if spread upon glass or paper, does not dry, but retains its moisture. From this circumstance, and its perfect neutrality, it may be employed in Photography as a means of preserving the moisture of sensitive collodion films and papers.

Glycerine is oxidised, after a time, by nitric acid, with the formation of oxalic and glyceric acids. When, therefore, glycerine is used as a preservative fluid in Photography, the nitrate bath should not contain much free nitric acid.

A great many salts which are soluble in water are also soluble in glycerine.

In the manufacture of soap, which consists in boiling a fatty substance containing glycerine with an alkali, the oil combines with alkali, and glycerine remains.

Glycyrrhizine (Greek, γλυκυς, sweet, ριζα, a root) is a sugar, or sweet resin, obtained from the liquorice root. A strong infusion of liquorice root is slowly evaporated to a small bulk, and sulphuric acid added: a precipitate falls, containing sugar and albumen. This is to be washed in water acidulated with sulphuric acid, and afterwards in water; then digested in alcohol, which dissolves the glycyrrhizine and leaves the albumen. A solution of carbonate of potash is then dropped into the alcoholic solution till its acid is neutralized; it is then filtered and evaporated, and the sugar remains as a yellow transparent mass.

It was at one time recommended to add this substance to collodion, for the purpose of increasing the density of the negative. No doubt it possesses that property at the expense of diminished sensitiveness. With our present photographic appliances there is no necessity for using it.

Gold. Au = 196·6. This valuable metal occurs in nature in a metallic state alloyed with silver or copper, and is then called *native gold*. The veins of gold are confined to primitive countries, but large quantities are collected in alluvial soils and the beds of rivers. It is generally found in small nodules and grains, but sometimes occurs in considerable masses weighing several pounds. The principal supplies of gold are from Australia and California, the Ural Mountains, the rivers on the west coast of Africa, and of Peru, Brazil, and Mexico.

Gold may be obtained pure by dissolving standard gold in *aqua-regia* (1 part by weight of nitric acid, and 2 of hydrochloric acid),

evaporating to dryness, re-dissolving the dry mass in distilled water, filtering, acidulating with hydrochloric acid, and then adding a solution of proto-sulphate of iron. A brown powder falls, which, after having been washed with dilute hydrochloric acid and distilled water, is pure gold. It may be fused in a crucible with a little borax, and a button of gold obtained.

Proto-sulphate of iron is a very delicate test for the presence of gold, producing a blue tint in a solution containing not more than the 60,000th part of the metal. It also throws down the whole of the gold from its solutions.

Gold melts at a bright red heat. It is so malleable that a single grain may be extended over 56 square inches of surface, and so ductile that a grain may be drawn out into 500 feet of wire.

No single acid has any action upon pure gold; neither has sulphur, nor sulphuretted hydrogen. Metallic gold, in a state of very fine division, has a purple tint.

Gold, Calcio-chloride of. A solution of this double salt of gold and calcium forms, in the opinion of some, the best toning bath for positive prints that has yet been devised. It is made thus:—

Dissolve 15 grains of common acid terchloride of gold in a pint of distilled water, and add to the solution 30 grains of dry, fresh chloride of lime. Shake well together several times during the course of a day or two, and then filter the liquid. It should be nearly colourless. When sufficiently diluted, it is the toning bath in question. It will keep indefinitely, and may be used to the last drop. If the colour of the liquid is too yellow, it will bleach the prints; in that case add more lime to it, and filter again.

Gold, Chloride of. $Au\ Cl_3 = 303{\cdot}1$. There are two chlorides of gold, viz., the protochloride and the terchloride. The latter is the one used in Photography. It is prepared by dissolving pure gold in *aqua-regia*, or a mixture of nitric and hydrochloric acids. As this salt is of great importance in Photography, and can generally be prepared by the photographic operator much more cheaply and of purer quality than he can purchase it, we shall describe the details of its manufacture somewhat fully.

Absolutely pure chloride of gold can only be made from the pure metal; but, as purity is not an essential for photographic purposes, the following method of making it from standard gold coin, which also applies to the pure metal, will be found convenient. It may be observed here that the pure metal is to be preferred when it is obtainable.

Mix in a rather tall and thin German beaker 2 fluid drachms nitric and 1 ounce of hydrochloric acid; place in the mixture a sovereign, and apply a gentle heat, which should be continued till the solution is complete. A water bath or a warm hob will give sufficient heat to commence and continue the action. No water need be added; but it may sometimes occur, when the acids are weak, that complete solution of the metal cannot be effected. In that case add a little more of the acids mixed in the same proportions. A great excess of acids should be avoided, because it renders their neutralization or their subsequent elimination more difficult.

The solution, when completed, will be of a greenish tint, from the copper alloy contained in the gold. The copper can be precipitated if necessary, by diluting the solution and adding bi-carbonate of soda; but really the presence of copper, we find, has no bad effect whatever. It is better, therefore, not to complicate matters nor to run chances of waste and failure by attempting to do so. The excess of acids, however, must be got rid of. To do so, dilute down the solution, with, say, 2 ounces of water, and pour it into a porcelain evaporating dish. Rinse out the beaker with another ounce of water, so as to waste nothing. Pour this also into the evaporating dish. Then place the evaporating dish on a sand bath heated by a gas flame, or, in the absence of that, on a stove not over-hot. When all the liquor is evaporated, a mass of crystals remain, which are the double salt of gold and hydrogen, with some nitric acid. Dissolve them again in 3 ounces of water, and again evaporate. Repeat the operation several times if necessary, till nearly the whole of the acid is driven off, which can be at once detected by the salt deliquescing, or again becoming liquid when the heat is removed. Then put it in solution in a measured quantity of water with some powdered chalk. The chalk has the effect of neutralizing the last traces of the nitric or hydrochloric acids which may still remain. Keep in a stoppered bottle in the dark, because light has the effect, after a time, of reducing the chloride of gold from neutral or even slightly acid solutions. All this may seem tedious, but really little attention is required when one has got the means and materials at hand.

Now to calculate the strength of gold in the solution. A sovereign contains 113 grains of pure gold. This, according to the tables of atomic weight, would yield 174 grains of pure chloride, thus:—

At. wt. of gold.	Wt. of gold.	At. wt. of chl. of gold.	Grs. of chloride.
196·6 :	113	303·1 :	174

And so for any weight of gold which it may be required to dissolve.

Supposing, then, the chloride of gold thus made from a sovereign is diluted with 20 ounces of distilled water, each ounce will contain 17 grains of the chloride—the other 4 grains may be laid to the account of waste, or a light sovereign.

Gold, Fulminating, is a brownish substance formed when ammonia is added to a strong solution of chloride of gold. It explodes most violently when heated, or by friction. Photographers, therefore, should be very careful, in neutralizing acid solutions of chloride of gold, not to do so with ammonia.

Gold, Hyposulphite of. *See* "Sel d'Or."

Green Pictures. If paper be floated on, or brushed over with, a sixty-grain solution of nitrate of uranium, and then exposed for about ten minutes under a negative, scarcely any visible effect is produced; but if it is afterwards washed in plain water and brushed over with a weak solution of ferrid-cyanide of potassium, the picture comes out red. While the paper is still moist with washing water, immerse it in a weak solution (about 10 grains to the ounce) of sesquichloride of iron; the tone will soon merge into a bright green.

Ground Glass. A sheet of ground glass is generally used for the focusing screen of the camera. It should be as finely ground as possible, and the best way to secure this is to use plate glass which has not received the final polishing in the manufacture. A sheet of plate glass may be ground by hand, by rubbing it with a smaller piece of thick plate, and the finest powdered emery moistened with water between. It takes three or four hours continuous labour to do this properly. The last and finest grinding may be given with a mixture of colcothar (red oxide of iron, iron rust) and water, instead of emery.

The ground glass screen should be placed in the camera with the ground side next to the lens; and it will be found very useful to mark two diagonals across it, and also one central horizontal line, and an odd number of vertical lines, with a lead pencil.

A good substitute for a ground glass focusing screen may be made by coating a piece of plate glass with solution of starch.

Guaiacum. A resinous exudation from the *Guaiacum officinale*, a lofty tree, native in Jamaica and St. Domingo. It is soluble to the extent of 90 per cent. in absolute alcohol. If a piece of paper be dipped in tincture of guaiacum, and exposed to the prismatic spectrum, it is oxidised, and becomes of a green tint in the violet rays; but in the red rays the green colour is said to be destroyed.

Gum. Gum is a substance which occurs largely in the vegetable kingdom, and is characterized by forming a viscid adhesive solution with water, which precipitates by the addition of alcohol a white magma. It occurs in the form of an exudation upon the bark of trees, and collects into drops, which gradually harden by exposure. There are two principal modifications of gum, one of which is well represented by gum arabic, and the other by gum tragacanth.

Gum Arabic. This is the produce of various species of *acacia*, and is imported from the Levant, Barbary, Senegal, the Cape of Good Hope, and India. It is soluble in cold water, but more rapidly in boiling water. Its solution is acid, and reddens litmus paper, from the presence of permalate of lime. It is insoluble in alcohol, ether, and oils. It enters into combination with some of the metallic oxides.

Gum Dammar, or, more properly, Dammar Resin. This is a white resin brought from India, and obtained from the *Pinus dammara.* It is soluble in benzole, and makes a tolerably good varnish for photographs upon glass, which dries very quickly without heat. A portion only of Dammar is soluble in alcohol.

Gum Dragon. Same as Gum Tragacanth.

Gum Process. This is a dry collodion process, in which gum arabic is the preservative used. A trace of free nitrate is left upon the sensitive plate, along with the solution of gum; the exposure is the same as for a wet collodion plate; and the development is effected in the old-fashioned way, with acid pyrogallo-nitrate of silver. Some excellent results have been obtained by this process, but the conditions of uniform success have not been ascertained. Since the discovery of the alkaline developer—which does not seem to suit the gum preservative—the TANNIN and NEW FOTHERGILL processes must be considered more worthy of notice, and the gum process as a thing of the past. Gum has the rather serious defect of causing the film to blister during the development and subsequent washings.

Gum Tragacanth. This gum is obtained from the *Astralagus tragacanther*, which grows in Crete and the surrounding islands. It looks like twisted ribands, and is of a reddish-white colour, nearly opaque, and a little ductile. When plunged into water, it dissolves in part, swells considerably, and forms a thick mucilage, which, when boiled with water, resembles a solution of gum arabic. It is very

difficult to pulverize, and should be heated to 212°, and pounded in a hot mortar.

Gun Cotton, or Pyroxyline. The manufacture of this important substance is described in the article "Pyroxyline."

Gutta Percha. This useful article is the produce of a very large and lofty forest tree called the *Isonandra gutta*, which is native in the islands of the Indian Archipelago. Some of its properties were first pointed out by Dr. W. Montgomerie in a letter to the Bengal Medical Board in 1843. When an incision is made in the bark of the above tree, a white substance exudes which becomes shortly, by exposure to air, hard and tough; this is pure gutta percha. Neither the wood nor fruit of the tree appear to be of any great value; and a full-sized tree, when cut down and the gutta percha collected in bamboos, yields about 30 or 40 pounds of gutta percha.

Gutta percha is sometimes contaminated with organic matters, bits of bark, and foreign substances. To purify it, it is rasped in cold water, which removes the greater part of the soluble organic matters and salts, and also facilitates the removal of portions of wood and earthy matters; for gutta percha does not combine with any substance of this kind, but merely holds it mechanically. The raspings are then washed and left to soak in warm water for several hours, and are finally dried, heated to about 230°, and kneaded into lumps.

Gutta percha may be softened by hot water, and in that state moulded into any form, stretched into sheets or straps, drawn out into tubes or threads, &c., and on cooling completely it hardens and retains the form given to it. It does not possess at any temperature the peculiar elasticity of india-rubber.

Gutta percha resists the action of cold water and damp, and all those agents which promote fermentation. It is not acted on by alkalis, even when caustic and in their most concentrated forms; nor by ammonia, saline solutions, water containing carbonic acid, the various vegetable and mineral acids, and alcoholic liquors.

Olive oil dissolves a small portion of it when hot, but precipitates on cooling. Sulphuric acid, with one equivalent of water, colours rown, and disintegrates it with a sensible evolution of sulphurous d. Hydrochloric acid attacks it slowly, and renders it brittle at mperature of 68°. Monohydrated nitric acid attacks it rapidly, h effervescence and an abundant evolution of fumes of hyponitrous l.

Only a small portion of gutta percha can be dissolved, even with t, in absolute alcohol or ether. Benzole and spirits

of turpentine dissolve it partially when cold, and nearly completely when hot. Sulphide of carbon, and chloroform, dissolve it completely when cold, the solution becoming perfectly clear and almost colourless when filtered under a bell glass.

Gutta percha is sometimes vulcanized with sulphur, by a process patented by Mr. Hancock in 1847. It is sometimes treated with chloride of zinc. The object of these processes is to give it a hard glazed surface free from stickiness. Vulcanized gutta percha may be varnished with a mixture of oil and resin, and polished till it acquires the lustre of japanned ware.

Gutta percha is sometimes adulterated with the gums of other trees, plaster of paris, &c.

It is an exceedingly valuable material for the baths and dishes used in Photography, but when employed for these purposes it should be scrupulously pure.

It has a porous texture, and its cells contain air. They may be clearly seen in a thin film of gutta percha placed under a powerful microscope.

Gutta percha is of great value to the surgeon for forming splints for fractured bones, since it can easily be moulded to any shape when hot, and becomes sufficiently hard and rigid on cooling. It is also very useful for many surgical instruments.

Halation. This name has been given to the following curious effect observable in photographic pictures which have been developed upon iodide of silver, either after an exposure in the camera—as in the case of daguerreotype and collodion positives, and collodion, albumen, and paper negatives—or after exposure in the printing frame, as in the case of a developed print. The appearance, as shown in the positive, consists of a narrow belt, or halo of light, surrounding the edge of a dark object; and the effect is to give a disagreeable and unnatural hardness to the outline. Halation is confined to the case of a developed photograph upon iodide of silver, and it is due to some peculiarity of that iodide, for it does not occur under similar circumstances when other salts of silver, as the chloride or bromide, are used. The cause of this peculiarity is unknown, and it would be unprofitable waste of space in this work to offer any hypothesis respecting it.

It is owing to halation occurring in a very marked degree in albumen negatives upon glass, when only iodide of silver is present in the sensitive film, that prints from such negatives exhibit the peculiar hardness and distinctness of detail for which they are remarkable.

Halogens. Haloid Salts. (Greek, αλς, sea salt; ειδος, form.) Haloid salts are such as are formed by the combination of a salt radical such as chlorine, iodine, bromine, &c., with a metal such as sodium, cadmium, &c. Chloride of sodium, iodide of potassium, bromide of cadmium, &c., are haloid salts; and chlorine, bromine, iodine, &c., are called "halogens."

Heliochromy, or the art of taking photographs in natural colours, is still a dream of the future, but there already exist indications that it will some day be realised. The great pioneer in this, as in many other photographic processes, was Sir John Herschel, who, as early as the year 1840, found that silver-chlorised paper, when blackened in the sun and exposed to light beneath differently coloured glasses, assumed the colour of the glasses. In the year 1848 M. Becquerel obtained all the colours of the spectrum on a prepared daguerreotype plate. M. Niépce de St. Victor, following in the same direction, produced still more brilliant specimens on silver plates, but unfortunately no means of fixing such prints have yet been devised.

M. Poitevin has made greater progress still, and in the course of the year 1866 has succeeded in partially fixing the coloured image imprinted on paper containing subchloride of silver. Many of these pictures are extremely interesting, because they show what *may* be done in this direction at some future day. Nothing really practical, however, has as yet come out of these processes; a description of them is therefore beyond the scope of this Dictionary.

Heliography. (Greek, ἥλιος, the sun; γραφω, to delineate.) Another name for Photography.

Hermetical Seal. A vessel is said to be "hermetically sealed" when its lips are closed together perfectly by means of heat, as in the case of a thermometer tube. The term is derived from Hermes, the fabulous founder of Egyptian chemistry.

Honey Process. This is a wet collodion process, in which honey is applied to the sensitive film, in order to keep it from getting dry when a long time elapses before the exposure and development. It was originally suggested by Mr. Shadbolt to employ honey in this way, and some very good negatives have been taken means of it. Golden syrup would, however, be better than y, on account of its not containing grape sugar.

o apply the syrup, mix together equal quantities of it and of enty-grain solution of nitrate of silver in water, and apply the ure to the plate after removing it from the nitrate bath.

Develop with acid pyrogallo-nitrate of silver, after having washed off the syrup.

Horn Silver. Fused chloride of silver, sometimes called "luna cornea;" a grey semi-transparent concrete mass, which is darkened to a slaty tint by exposure to light. The melting point of horn silver is 500° Faht. If heated much above that point it volatilizes in dense white fumes. When cooled slowly after fusion it has a tending to octahedral crystallization.

Hungarian Solution. This liquid is sometimes used in the daguerreotype process for exciting the plate at one operation. Its composition has not been published, but it is supposed to be a dilute alcoholic solution of iodine, bromine, and chlorine, in certain proportions. Its use is now nearly superseded by that of bromide of lime.

Hydrate. When water enters into direct combination with a body, the compound is called a hydrate of that body. For instance, water combines energetically with slaked lime, and the compound is called "hydrate of lime." Sometimes water combines less energetically with bodies, and merely in such a way as to constitute what is called their water of crystallization, which may be expelled by heat; in this case the term hydrate is not employed.

Hydriodates. Salts formed by the combination of hydriodic acid with bases. Sometimes a salt is called a hydriodate of a base when it ought more properly to be termed an iodide of a metal. Iodide of potassium, for instance, contains no water of crystallization, and the term hydriodate of potash is therefore incorrectly applied to it. The same may be said of many hydrochlorates, hydrosulphates, &c.

Hydriodic Acid. $HI=128$. This acid is a combination of equal volumes of hydrogen and iodine, which unite in the gaseous form without decrease of volume. It is obtained by gently heating 1 part of phosphorus, 14 of iodide of potassium, 20 of iodine, and a little water. The formula of the reaction is, according to Gmelin,

$$2\,KI+5\,I+P+7\,HO=2\,KO,PO_5+7\,HI.$$

Hydriodic acid may also be formed by passing a mixture of hydrogen and the vapour of iodine through a red-hot iron tube. The acid gas may be collected over mercury, but is soon decomposed by the mercury, which takes a part of the iodine.

Hydriodic acid gas is extremely sour, and reddens litmus paper, colourless, and exhales fumes in the air. It extinguishes flames,

and is not inflammable. It may be liquefied under pressure, and becomes solid at a temperature of $-60°$ Faht. It is not permanent at a red heat. Chlorine decomposes hydriodic acid, producing hydrochloric acid and iodine, and chloride of iodine. Nitric acid decomposes it with great violence, and in general, oxidizing agents decompose it by forming water with the hydrogen, and liberating iodine.

Hydriodic acid gas mixes readily with water. The sp. gr. of the strongest liquid acid is 1·7. It becomes dark coloured when kept in contact with air, in consequence of a partial decomposition. Aqueous hydriodic acid may readily be produced by passing sulphuretted hydrogen through a mixture of iodine and water; the sulphur is precipitated, and hydriodic acid produced. On heating and filtering the liquor a pure solution of hydriodic acid is obtained.

Hydrobromic Acid. $HBr = 81$. This acid very closely resembles hydriodic acid in its preparation and in all its reactions. It may also be prepared exactly in the same way by only substituting an equivalent of the one body for the other. A solution of it will dissolve a large quantity of bromine.

Hydrochloric Acid; $H\,Cl. = 36·5$. This acid is sometimes called "muriatic acid," and "chlorhydric acid." It is formed by combining equal volumes of hydrogen and chlorine, which unite without diminution of volume, the result being a strongly acid gas. The simplest mode of effecting this combination is to expose the mixed gases to light. In diffused daylight they combine gradually, but in strong sunshine at once, and with explosion. If a mixture of equal volumes of hydrogen and chlorine be collected over water in a tall graduated glass jar, and exposed to diffused light, the gases gradually combine and form hydrochloric acid; this is absorbed by the water, which has a strong affinity for it, as fast as it is formed, and the water therefore rises in the tube. It is found by this experiment that the quantity of acid produced is proportional to the time of exposure to light.

Hydrochloric acid is readily obtained by adding diluted sulphuric acid to common salt in a retort, and applying heat to the mixture. The chlorine of the salt combines with the hydrogen of the water to form hydrochloric acid, the sodium is oxidized, and sulphate of soda left in the retort.

Dry hydrochloric acid gas is colourless, and fumes in the air from its absorption of moisture. It is intensely sour, and combines readily with water. The sp. gr. of the strongest liquid acid is 1·210,

and water takes up 500 times its bulk of the gas. It boils at ·112°, and freezes at – 60°.

The impurities in commercial liquid hydrochloric acid, and which give it a yellowish colour, are principally organic matter (from bits of cork, lute, &c.), a trace of bromine, chloride of iron, sulphuric acid, and sometimes nitric and sulphuric acids, and also a trace of arsenic. By adding chloride of barium, and redistilling the acid, the principal impurities are removed.

Hydrochloric acid acts on some of the metals, and produces corresponding chlorides. It precipitates chloride of silver from the soluble salts of the oxide.

Hydrocyanic Acid; Prussic acid; C_2 NH, or H Cy.=27. Hydrogen and cyanogen have no tendency to direct combination, but hydrocyanic acid may be produced by acting on cyanide of mercury with hydrochloric acid, distilling the mixture with a gentle heat, and surrounding the condenser with ice. Anhydrous hydrocyanic acid thus obtained is a limpid liquid having a strong odour like that of bitter almonds. It scarcely affects the blue of litmus, and is decomposed by light, with the evolution of ammonia. It is so extremely volatile that a drop of it let fall upon a glass plate freezes itself. It combines readily with water.

Hydrated hydrocyanic acid may be readily obtained by distilling a mixture of equal parts of cyanide of potassium and sulphuric acid; the cyanide being dissolved in twice its weight of water, and the sulphuric acid diluted with three times its weight of water.

This acid is highly poisonous; the most effective antidotes are ammonia and chlorine. Its sp. gr. is not a correct criterion of its strength. Added to a solution of nitrate of silver it throws down insoluble cyanide of silver.

Hydrofluoric Acid. HF=20. This acid is obtained by distilling finely powdered fluor spar (fluoride of calcium), with twice its weight of sulphuric acid. The acid which passes over is a highly volatile and corrosive liquid, which acts powerfully on glass; the retort should therefore be made of lead, and the tube and receiver of platinum, and the latter surrounded with ice. This acid must be kept in a leaden or platinum bottle. It is colourless, fumes in the air, and has a most powerful affinity for water, exceeding that of oil of vitriol. When dropped into water it hisses and evolves great heat. It acts vigorously on the skin, and produces bad sores and dangerous ulcers, if carelessly handled.

The characteristic property of hydrofluoric acid is the energy with which it attacks glass, producing heat and effervescence when

dropped upon it. Diluted with 6 times its weight of water, it is used for etching upon glass. The fumes of hydrofluoric acid destroy the polish and dim the surface of glass. Focusing screens are sometimes made in this way instead of by grinding the glass.

Hydrogen. H = 1. (Greek, ὕδωρ, water, and γεννειν, to produce).

Hydrogen is the lightest of all known bodies, and its atomic weight is therefore taken as the unit of the scale of equivalents. It may be obtained in a somewhat impure form by acting on some bits of zinc, or iron filings, with dilute sulphuric acid. Water is decomposed, its oxygen going to the metal to form a sulphate, and hydrogen being given off. The best proportions appear to be, zinc 3 parts, sulphuric acid 5 parts, water 25 parts. Pure hydrogen may be obtained by acting on pure water with an amalgam of potassium or sodium. Hydrogen may also be obtained by passing steam through a red-hot gun-barrel.

Hydrogen is inflammable, but extinguishes flame. When mixed with oxygen or atmospheric air in sufficient quantity it explodes with violence. It has a high power of refracting light. When pure it is colourless, tasteless, and nearly inodorous. Water only takes up about 1 per cent of it.

Hydrogen plays an important part in many of the chemical changes produced by light.

Hydrogen is supposed by many chemists to be a metal in the form of vapour, and to be the acidifying principle of some acids. Take, for instance, sulphuric acid; this substance, so powerful an acid in its hydrated or common form, does not, when pure and perfectly *anhydrous*, redden litmus paper, or exhibit any acid properties. Other similar cases might be quoted.

Hydrogen, Peroxide of. $HO_2 = 17$. This curious compound was discovered by Thenard in the year 1818. The preparation is very complicated and tedious. The rationale of the process consists in acting on the peroxide of barium, sodium, &c., by any diluted acid which forms a soluble salt with the base. The oxygen which is driven off from the peroxide does not escape, but actually combines with the water, converting it into peroxide of hydrogen.

Peroxide of hydrogen is a powerful oxidizing, and, strangely enough, also a reducing agent. In virtue of its former property, it has been recommended by Dr. Smith, of Manchester, as a very convenient method of converting the last traces of injurious hyposulphites, which exist in all photographic prints, into the innocuous

sulphates. This it does by oxidizing the hyposulphites. But Dr. Reynolds, of Dublin, has shown that it acts on the hyposulphites in two ways. It not only oxidizes but at the same time it reduces them. For this reason it is not likely that this substance will be much employed in Photography.

Hydrometer. An instrument for measuring the specific gravities of liquids. Its commonest form is a long graduated tube, loaded at the bottom, and allowed to float in the liquid to be tested, the depth to which it sinks being indicated by the scale. The principle of the instrument consists in the fact, that a floating body displaces a quantity of liquid exactly equal in weight to itself. The hydrometer affords, therefore, a measure of the volume of the liquid necessary to counterbalance in weight the weight of the instrument; and by comparing these measures of volume when different liquids are tested, the specific gravities of the respective liquids may be compared and determined.

The most convenient form of hydrometer on this principle is that of Zanetti, manufactured at Manchester. It is sold in sets of six, and the sp. gr. is got by adding a cypher to the number of degrees indicated; the assumed temperature being 60° Faht.

The hydrometers of Twaddle and Beaumé, are constructed on the same principle, but graduated differently, There are two forms of Beaumé's hydrometer; one for measuring the sp. gr. of liquids heavier than water, and called a "*pèse-acide*," or "*pèse-sirop;*" the other, for liquids lighter than water, and called a "*pèse-esprit.*" These instruments are much used both in France and England, and are sometimes called "Areometers."

An entirely different principle of construction has been adopted in the hydrometers of Nicholson and Fahrenheit. In these instruments the line of floatation in water at 60° is marked, and when immersed in the liquid to be tested the instrument is loaded until it sinks to the same level—the weight required to be added or removed determining the sp. gr. of the liquid.

The hydrometer does not afford an exact test of the strength of an *old* nitrate bath, because the bath acquires by use nitrate of potash and other contaminations, which increase its specific gravity; but it affords a sufficiently good test for most practical purposes.

Hydrosulphuric Acid; Sulphuretted hydrogen; $HS = 17$. Sometimes called hydro-thionic acid.

This gas is readily obtained by acting on proto-sulphide of iron by dilute sulphuric acid; or by heating in a flask equal parts of tallow and powdered sulphur. In the former case water is decom-

posed, the hydrogen combining with the sulphur to form hydrosulphuric acid, and the oxygen going to the iron to form protosulphate of iron. The second method yields the purest gas.

At ordinary temperatures hydrosulphuric acid is gaseous; it is liquefied under a pressure of seventeen atmospheres, and becomes solid at a temperature of – 122° Faht. It is inflammable, but extinguishes flame; highly poisonous, and its odour extremely offensive, resembling that of rotten eggs. Cold water takes up about three times its volume of this gas, and the solution is slightly acid to litmus paper.

Hydrosulphuric acid throws down silver, gold, and many other metals from their solutions, by forming insoluble sulphides, of various colours; *see* "Sulphides." It combines with many of the basic sulphides and forms double sulphur salts.

Hydrosulphuric acid is immediately decomposed by iodine, chlorine, and bromine, and sulphur precipitated. It is also decomposed by nitric acid. In combination with potash, or soda, it is capable of dissolving gold, and forming a double sulphide of gold and potassium or sodium. Silver may probably be acted on in the same way, and the yellow material of a faded photograph may be a double sulphide of silver and sodium.

Hypochlorites. These substances are prepared commercially by passing chlorine gas through solutions of hydrated or carbonated alkali, thus forming a chloride and a hypochlorite simultaneously. They are oxidizing agents. For this reason they have been recommended by Mr. Hart for the purpose of eliminating the last traces of hyposulphite of soda from washed photographic prints. It is very probable that a very weak solution of a hypochlorite will effect this object. But a great and almost fatal objection to their use is, that the chlorine also combines with the silver in the print, forming a white chloride of silver, thus reducing the vigour of the image considerably.

Hyposulphites of Gold and Soda. *See* "Sel d'or."

Hyposulphites. Many of the metallic oxides combine with hyposulphurous acid and form hyposulphites, but at present none of them possess much interest in Photography except those of soda, gold, and silver; *q. v.* The hyposulphites of all the alkalies, and alkaline earths, mostly act in the same way as that of soda in dissolv- g the haloid salts of silver.

ce. Water solidified by cold. Ice is in general pure water, for n water freezes it rejects all saline matters and impurities;

melted ice may therefore be used in Photograghy instead of distilled water. This may sometimes be found a convenience to the photographic tourist on the continent, since ice can be obtained at the hotels of all large continental towns. The melting point of ice is 32° Faht., and 0° Centigrade. Water may be frozen by artificial cold produced by various freezing mixtures; *q. v.*

Iceland Moss. *Cetraria Islandica.* A lichen which grows in exposed places in Iceland, and is used by the natives as food. When boiled with water, and allowed to cool, it forms a jelly. It is sometimes used in Photography instead of gelatine, which it resembles in its properties.

Iceland Spar. Native carbonate of lime, crystallized and pure. The crystals exhibit the phenomenon of "double refraction" (*see* "Light"), and are used in experiments on polarized light. Their form is an obtuse rhomboid of 105° 5′ and 74° 55′, according to Dr. Wollaston. They are not always transparent, but sometimes opaque, or snow white, or tinged of different hues.

Illumination. The illumination of a surface varies inversely as the square of its distance from the source of light. The same quantity of light which falls upon a certain area at a distance of 1 foot from the luminous body will be extended over 4 times that area at a distance of 2 feet, 9 times at a distance of 3 feet, 100 times at a distance of 10 feet, and so on. This is evident from the consideration of the sections of a pyramid made at distances 1, 2, 3,—10 from the vertex. Hence the rule stated above.

Image. A term used in optics to denote an assemblage or system of foci. When the foci are "real" the image is "real," and when "virtual," "virtual," (*see* "Focus"). The image formed by the lens of a camera obscura is a "real" image, and it illuminates a screen placed to receive it; the image formed by a looking-glass is not a real but a virtual image. In the former case the rays actually pass through the image, in the latter it is only the directions of the rays produced backwards which pass through the image.

In optics a luminous body is considered to be an assemblage of luminous points, from each of which a pencil of light proceeds, these pencils not interfering with one another. Each pencil being then refracted through a convex lens, its rays are brought to a focus. This focus is sometimes called the image of the luminous point which emits the rays that are collected in it, and the assemblage of all these foci constitutes the image of the object.

The distinctness of the image will depend upon the accuracy with which the rays of each particular pencil are brought to a focus.

Since the objects are in general at different distances from the lens, the image does not necessarily lie upon a plane or upon any regular curved surface.

Image, invisible. It is well known that when a collodion or other film, containing a haloid salt of silver, is exposed in the camera, no visible image is apparent until a developer or deoxydizing agent is employed. Many speculations have been made as to what the real action of light has been on the sensitive tablet while exposed to its action. Some say it is mechanical or molecular, because the most delicate tests can detect no chemical difference between the parts which have been exposed to light, and those which have not. The advocates of this theory argue that, as no chemical action has taken place, the only effect of light has been to disarrange the molecular condition of the haloid compound in such a way as to render the particles susceptible to the influence of a developer which reduces the silver at those parts where the molecular disturbance has occurred. Others hold what is called the chemical theory, and argue that light has really commenced a decomposition or rather a reduction of the silver in the sensitive film, which is completed by the developer. The analogy of the behaviour of some haloid salts of silver which are undoubtedly reduced by light, is in favour of the "chemical" theory; but, again, those who entertain the "physical" theory challenge the chemical theorists to show the grounds on which they found their claims. The arguments are strong on both sides; but so long as the question is not settled definitively, its discussion in these pages would be out of place.

Imperial Measure. *See* "Tables of Weights and Measures."

Imponderable Agents. Light, Heat, and the various forms of Electricity are called "imponderable agents," because they have not yet been weighed. Matter is whatever can be proved to possess weight, that is, to be subject to the law of gravitation. Light and Heat are the undulations of a medium so subtle that it has not yet been weighed; and neither light, heat, nor electricity perceptibly ct the weight of bodies that are affected by them; hence they alled imponderable or immaterial agents; the terms "impon-ole" and "immaterial" being strictly synonymous, according to lefinition of matter.

is probable that light, heat, and the various forms of electricity all be undulations of an elastic medium pervading space, which,

although its weight may not be appreciable by our senses, aided by any form of apparatus, may still possess weight, and be material. This subtle but material ether may be supposed to fill the interstices between the atoms of bodies, and by its motions to disturb their relative positions in such a way as to produce the phenomena due to what are called the "imponderable agents." The difference between light, heat, and electricity would depend, according to this hypothesis, upon the kind and length of the undulation, and the velocity of its propagation; so that these agents may actually glide one into the other, and become merely modified cases of one form of matter in motion. But these are speculations; let them not be confounded with ascertained facts. Still, speculation is a necessary part of philosophic inquiry; and as for the undulatory theory of light, that is now received by scientific men with the same faith as the law of universal gravitation. Both hypotheses rest upon equally strong evidence, and there is the highest degree of moral certainty of their truth.

Incidence, Angle of. When a ray of light is incident upon the surface of any medium, the angle which it makes with the normal to the surface at the point of incidence is called the "angle of incidence."

Incorrodible Ink, used for writing the labels of bottles containing strong acids or alkalis:—Dissolve one part of asphaltum in two parts of oil of turpentine.

Indian Ink. Pure indian ink is manufactured in China. A very good imitation may be made in the following manner:—

Grind together lamp-black (previously purified with caustic potash) and gelatine, the gelatinizing power of which has been partly destroyed by long continued boiling. It may then be scented with musk and a little camphor, and made into sticks.

Indian ink is used in Photography for blackening the skies of collodion and paper negatives, and for touching up positives. It may be made extemporaneously by blackening the inside of a plate over the flame of a candle, and mixing up the lamp-black thus obtained with a little gelatine water.

Indigo. This valuable dye and pigment is of vegetable origin, and comes principally from India, being manufactured from the leaves and stems of the indigo plant. There are also West Indian, Egyptian, and Arabian varieties. Indigo is also obtained from woad.

The seeds of the plant are sown in the spring, and the plant is cut

as it comes into blossom. Sometimes the indigo is obtained from the fermentation of the fresh leaves and stems, at other times from the dried leaves. An infusion is made which after fermentation is of a yellowish or greenish colour. It is then decanted and beaten with sticks for some time, which expels the carbonic acid from the liquid, and brings the particles of indigo into contact with the oxygen of the air; they then separate in grains and fall to the bottom of the vessel, the liquid becoming clear.

Indigo is a dark blue powder, devoid of taste or smell, insoluble in water, cold alcohol, ether, hydrochloric acid, and fat oils, but soluble in *strong* sulphuric acid, and creosote. The commercial sample contains scarcely one half of pure indigo, the remainder being composed of resinous substances, silica, alumina, oxide of iron, carbonate of lime, &c.

When indigo is placed in contact with a substance having a strong affinity for oxygen, it parts with oxygen and takes hydrogen, losing its colour, and forming white indigo (indigotine) by exposure to air and heat. This again absorbs oxygen, and acquires its former blue colour. White indigo is soluble in alcohol and ether, and is very unstable. Although, therefore, many substances may deprive indigo of its colour, yet it has always a tendency to recover it by becoming again oxidized.

Indigo dissolved in strong sulphuric acid forms a deep blue liquid, called sulphate of indigo.

Indigo is likely to prove a valuable substance in the photographic process of printing in pigments.

Inflexion of Light. *See* "Light."

Ink. Common black writing ink is tannate of iron. It is made thus:—

Take Bruised nut-galls	12	parts.
Sulphate of iron	4	,,
Gum arabic	4	,,
Water	120	,,

Mix together in a stone bottle, and let them stand for two or three weeks, shaking the bottle from time to time. Then, pour off the clear liquor, and add a little creosote to prevent mouldiness.

If an ounce of treacle be added to a pint of common black writing ink, the writing may be transferred by means of a copying machine.

Ink, Indelible. Berzelius's indelible ink is made by adding a eak solution of vanadate of ammonia to an infusion of galls. A ɜry small quantity of the salt will produce a perfectly black ink.

Ink-Printing Process. By this process positive prints may be obtained in common writing ink.

The paper is first immersed in a nearly saturated solution of bichromate of potash, and dried in the dark. It is of a bright yellow colour.

It is then exposed to light under the negative, in the pressure frame, until all the details of the picture are brought out. The time required is less than that in ordinary sun-printing. The picture is of a pale brown tint upon a yellow ground.

The picture is then washed in water, in order to remove the whole of the undecomposed chromium salt. The water should be changed several times, and the print left to soak in it for two or three hours. This should be done in the dark room.

When the print has been sufficiently washed, it may be taken into the light, and the picture, which is now a pale brown upon a white ground, is permanently fixed, the dark material being an oxide of chromium in combination with the lignin of the paper.

It now remains to colour the print black or purple. This is done by causing writing ink to adhere to the dark parts of the picture, which act as a mordant.

Immerse the print for a few minutes in a weak solution of protosulphate of iron, say 5 grains to the ounce of water. Then remove it, and wash it as before in several changes of water, and let it soak for two or three hours in water. The iron salt adheres to the image or mordant, but in much less quantity to the bare lignin of the paper.

Next, immerse it in a solution of tannic acid, of moderate strength. The dark parts of the picture are rapidly blackened by the formation of tannate of iron, or writing ink; the lights remaining unchanged. When fully developed, wash the print well in water, and dry it. It is now finished.

The difficulties of the process consist in thoroughly removing the chromium and iron salts from the paper, so as to preserve the purity of the whites; and also in obtaining blacks of sufficient depth and vigour. The prints are uniform in colour, and the detail is good; the process is also very economical. The paper may either be albumenized or gelatinized by mixing albumen or gelatine with the bichromate of potash. These organic substances are fixed and rendered insoluble by the reduction of the chromium, and are washed out from the parts where light has not acted. The details of the picture are therefore glazed upon a dead ground of white paper. The most vigorous prints are obtained upon unsized paper, but this is very liable to get torn in the operations of washing.

Insolation. Exposure to sunshine.

Instantaneous Dry Collodion Processes. A dry collodion plate, prepared with a collodion containing not less than 2½ grains of bromide of cadmium to the ounce, together with the usual quantity of iodide of cadmium, may be successfully developed into a good negative, after receiving the same exposure as a good wet collodion plate, provided the alkaline developer be employed and a preservative of tannin. Mr. Fothergill's new dry process (*q. v.*) is also an instantaneous one. For further information consult a treatise by Mr. Sutton on the "Instantaneous Dry Processes," published by Messrs. Sampson Low and Co. Major Russell has obtained instantaneous pictures upon dry plates prepared with bromized collodion. *See* the second edition of his "Treatise on the Tannin Process," published by Hardwick.

Instantaneous Pictures. Photographs obtained in a fractional part of a second of time are said to be instantaneous. There is no particular process more sensitive than those in common use by which instantaneous pictures can be taken. Either the ordinary wet collodion process in its most efficient working state, the daguerreotype process, or one of the so-called instantaneous dry-processes, is employed for this class of pictures.

By means of collodion the finest results have been obtained. The conditions necessary for success are, chemicals in the best working order, a good light, and a lens with large aperture. Le Gray, Wilson, and England have exhibited very fine instantaneous pictures taken under such conditions, and Mr. McKinlay, of the Royal Arsenal, Woolwich, has gone so far as to be able to photograph a six hundred-pound cannon ball, at the moment of its projection from the muzzle of an Armstrong gun.

Instantaneous Shutters. There are many methods of instantaneously admitting and shutting off the light from the sensitive plate. Mr. Wilson, who has been the most successful in getting good pictures with rapid exposures, adroitly uses his "Highland bonnet" placed in front of the lens. Some use flap-shutters in front of the lens, some a similar arrangement close behind the lens, and Mr. England and others use a guillotine sort of shutter, with a slot cut across it, which falls immediately in front of the sensitive plate. As the slot passes the plate, the parts thus exposed to light ive the full effect of the whole power of the lens. In some ects this is the best instantaneous shutter that has yet been sed, but it is apt to cause a vibration in the camera while in the of falling.

Intensifiers. This term is used to denote those substances, which, when applied to a negative, serve to increase the actinic opacity of the deposit already formed. One class of intensifiers acts by increasing the deposit of silver forming the image. To this class belongs a mixture of protosulphate of iron and nitrate of silver, also pyrogallic acid and nitrate of silver. The latter method is most commonly adopted. Another class of intensifiers derives its value not from forming any new deposit, but from changing that already formed to a more non-actinic colour. To this class belong the alkaline sulphides, which blacken the silver deposit, and Schlippe's salt, which turns the deposit to a very non-actinic scarlet colour. Several other substances act after this fashion, but, as a rule, they are inferior to the first class.

Interference. *See* "Light."

Invisible Rays of the Spectrum. The invisible rays beyond the extreme violet are, for a certain distance, actinic, and darken sensitive paper. These rays are the most refrangible, and the undulations are the shortest. They may be rendered visible by being passed into a solution of sulphate of quinine. (*See* "Fluorescence.") The invisible rays of the spectrum beyond the extreme red are, for a certain distance, calorific, and their existence may be proved by the heat which they produce. These rays are the least refrangible, and the undulations have the greatest length. It is probable that both the rays of maximum actinic and calorific power lie within the limits of the visible spectrum; but this will depend upon the nature of the substance acted on.

Iodides are combinations of iodine with a metal or with acid organic radicles. The metallic iodides only are used in Photography. A description of them will be found under the head of the different metals.

Iodine. (Greek, ιωδης, violet-coloured.) I=126. This elementary substance is contained in minute quantity in sea-water, and some mineral springs, but enters more largely into the composition of certain sea-weeds, chiefly found on the western coasts of Ireland and Scotland; a minute trace has also been found in cod-liver oil, and in the yellow sap of the "*Indus fœtedissimus.*"

Iodine is chiefly manufactured in Glasgow, from kelp. (*See* "Kelp.") This is lixiviated in cold water, and the solution gradually evaporated, when the various salts which it contains, and which are less soluble than the iodides, crystallize and are removed in succession. The dark mother liquor which remains contains the iodides.

From these the iodine is separated by distilling the liquid with sulphuric acid and black oxide of manganese. The iodine passes over as a violet-coloured vapour, which condenses in the alembic and neck of the retort in long pointed crystals of a dark colour, opaque, and having a metallic lustre. These are washed out with a little water, and dried with blotting paper. The process is minutely described in Dr. Graham's Elements of Chemistry.

Iodine is sparingly soluble in water, but dissolves readily in alcohol and ether. The commercial sample may be purified by dissolving it in alcohol and precipitating it with water. The impurities, or adulterations, are principally plumbago, sulphide of antimony, and black oxide of manganese, all of which are insoluble in alcohol. Iodine is dissolved by solutions of the alkaline iodides.

Iodine is extremely volatile when moist. At 120° it rises rapidly into vapour, at 220° fuses, and at 350° boils and produces dense violet-coloured fumes which crystallize in brilliant plates and acute octohedra. The aqueous solution of iodine does not evolve oxygen when exposed to sunshine, nor has it bleaching properties.

Iron, Ammonio-citrate of. This neutral double salt of citrate of peroxide of iron, and citrate of ammonia, dissolved in water, and mixed with solution of ferro-cyanide of potassium, gives a purple solution nearly black. Papers prepared with this are bleached in the light, but darken again in the dark. Salts of cyanogen, and salts of iron, are both subject to actinic action; but the iron is here the one attacked This paper may be used to take evanescent pictures of many objects successively. The ammonio-citrate of iron itself is a beautiful pharmaceutical preparation. It is a salt of the peroxide of iron, which is partially reduced by the chemical rays to protoxide. Papers prepared with a solution of it change by insolation from a bright yellow to an ochrey gray, and may be developed before the picture becomes visible by ferridcyanide of potassium (red prussiate of potash), which proves the reduction to the state of protoxide, by the formation of prussian blue. It is known to all photographers that the protosalts of iron, as the protonitrate, the protacetate, the protocitrate, &c., are developers, and their formation by light is a curious instance in which the usual order of operations in taking a picture is reversed. First, the paper is prepared with an iron persalt, which, by solar action, becomes a developer in certain - only of the paper, and the picture is then produced by the of this local developer on any salts applied uniformly to the which it is capable of deoxidising. Bichromate of potash, ; of silver, and many others may be thus applied, and appear

to develop the print themselves, but in truth only supply material to the invisible developer, which pre-existed on the surface.

Iron, Ammonio-sulphate of. This is a double salt of iron prepared by mixing equal equivalents of protosulphate of iron and sulphate of ammonia, that is, take 139 parts of photosulphate of iron and 75 of sulphate of ammonia, dissolve them in a minimum of water, and set aside in an evaporating basin till the double salt crystallizes. M. Meynier recommends it to be used as a developer instead of the plain protosulphate, chiefly on account of its greater stability. It seems to possess no other advantage.

Iron, Iodide of. $Fe\ I = 155$. Iodide of iron is formed by digesting iron filings or wire in water with pulverized iodine, the metal being in excess. A greenish solution is formed which is extremely unstable. By very careful evaporation crystals may be obtained which are soluble in alcohol.

When iodide of iron is used as an iodiser in collodion, protonitrate of iron is formed in the nitrate bath, and also in the film. This acts as a developer and speedily blackens and spoils the bath. It will also develop the image so long as the plate continues moist; the picture, therefore, comes out after exposure by a sort of spontaneous developing process. In consequence of this property of iodide of iron, it has been thought to give extraordinary sensitiveness to collodion; but that opinion is erroneous.

Iron, Perchloride of. $Fe_2\ Cl_3 = 162{\cdot}5$. There are two chlorides of iron; but that which generally goes under the name is formed by dissolving the peroxide ($Fe_2\ O_3$) in hydrochloric acid and evaporating to dryness. It is soluble in alcohol and ether, and deliquescent. The alcoholic solution is the *tincture* of the shops; boiling alcohol dissolves its own weight. Added to hyposulphite of soda, it produces sulphur compounds which impart good tones to photographs, but make them liable to fade: it acts on the soda compounds as free chlorine would, and loses chlorine. Mixed with iodide of potassium and spread over darkened chloride paper, it bleaches out the dark impression in the light, the potassium giving iodine, and the iron chlorine, which combine with the reduced silver.

Iron, Protacetate of. $Fe\ O,\ C_4H_3O_3$. This substance is sometimes used in Photography as a developer. It may be made of sufficient purity by mixing solutions containing equal equivalents of protosulphate of iron and acetate of lead, and filtering out the precipitated sulphate of lead. The solution very soon oxidises; it should therefore only be made as wanted.

Iron, Protonitrate of. $Fe O, NO_5 + 7 aq. = 153$. This salt is a deoxidising substance, obtained in solution by mixing solutions of protosulphate of iron and nitrate of baryta in equivalent proportions. It is very unstable, and becomes converted into *pernitrate* by exposure to the air.

Solution of protonitrate of iron may be used alone or in conjunction with the protosulphate as a developer of collodion positives. It is not an energetic developer, and when used alone renders the whites of the image very metallic.

Iron, Protosulphate of. $FeO, SO_3 + 7 aq. = 139$. This salt, sometimes called *copperas*, or *green vitriol*, is obtained by acting on iron wire or filings with dilute sulphuric acid, evaporating and crystallizing. When pure, the crystals are of a fine bluish green colour, free from red stains, and in the form of oblique rhombic prisms. They are insoluble in alcohol, which deprives them of their water of crystallization and precipitates the salt as a white powder. In dry air they effloresce, but in moist air become oxidised into a persulphate and assume a red colour.

Protosulphate of iron forms double salts with the sulphates of ammonia and potash. Its aqueous solution absorbs binoxide of nitrogen from the air and becomes of a deep olive colour. As binoxide of nitrogen is itself a reducing agent, it has been supposed by some, but erroneously, that the changed solution is a more energetic developer than the plain protosulphate.

Protosulphate of iron is a powerful deoxidiser, and is therefore used most extensively in Photography as a developer, almost to the exclusion of all others. There are some combinations, or rather mixtures of it, with gelatine and analogous substances, which give it the property of developing an extraordinarily vigorous image. *See* "Ferrogelatine Developer."

Ironstone Ware. This is a very good and suitable material for photographic baths, dishes, funnels, &c. Messrs. Edwards and Co., of Dalehall Potteries, Burslem, are large manufacturers of these articles, and they are most excellent, not only in quality but in pattern.

Isinglass. Fish glue; a pure form of gelatine. It is soluble in boiling water, and gelatinizes on cooling; it is also soluble in weak acids, but is precipitated by the addition of an alkali. Isinglass is obtained from the air-bladders of sturgeons, and principally from the great sturgeon found in the Caspian Sea. It is manufactured chiefly at Astracan, and is bleached by the fumes of burning sulphur. The process of manufacture consists in first steeping the

bladders in water, then removing the outer skin, putting them into a hempen bag, squeezing them, softening them between the hands and twisting them into small cylinders, which are afterwards beat into the shape of a lyre.

Isomerism. (Greek, ισος, equal; μερος, a part.) There are numerous instances in chemistry in which two bodies are identical in composition, but different in appearance and properties. Such bodies are said to be "isomeric."

For instance, cyanogen, which is a gas, is represented by the formula C_2 N, while paracyanogen, which is a black solid having different properties, has also the formula C_2 N.

The difference in properties between isomeric substances is supposed to proceed from a difference of arrangement of their atoms.

Isomorphism. (Greek, ισος, equal; μορφη, form.) There are many instances in chemistry in which similarity of properties is possessed by bodies, or classes of bodies, having the same form. This is remarkably shown in the case of the chlorides, iodides, and bromides, which are "isomorphous;" the term being applied to bodies which can replace each other in combination, without producing any essential difference in the crystalline form of the compound. Bodies may therefore be classed in isomorphous groups, the individuals of which possess, in many respects, similar properties.

Ivory. Ivory is the osseous matter of the tusks and teeth of the elephant, hippopotamus, wild boar, several species of seal, and the horn of the sea-unicorn. The latter furnishes the best ivory.

The composition of ivory is the same as that of the teeth of animals; viz., three parts phosphate of lime, and a little carbonate, with one part cartilage.

Photographs may be taken upon plates of polished ivory, and they have remarkable beauty and delicacy.

Ivory is liable to turn yellow by time. Its whiteness may be restored by moistening and rubbing it with pumice stone, and exposing it to sunshine while moist, under a glass shade, carefully sealed to the stand at the bottom, in order to retain the moisture and prevent the ivory from cracking.

Collodion positives may be taken upon dyed ivory. It may be dyed black by boiling it first in a decoction of logwood, and then in a solution of red acetate of iron; or violet, by first boiling it for a short time with proto-chloride of tin, and then in logwood. The sheets should be dyed first, and polished afterwards.

Ivory, Artificial. This has been made for photographic pur-

poses by mixing sulphate of baryta with albumen, and rolling it into sheets.

Pinson's artificial ivory, much used in France, is made by immersing a sheet of gelatine in alumina dissolved in acetic acid. The two combine, and when the gelatine has imbibed sufficient of the alumina, it is taken out, hung up to dry, and finally polished.

Artificial ivory may also be made by mixing ivory dust with albumen, and rolling the paste into sheets, then drying and polishing them. Mr. Burgess, of Norwich, has produced a very beautiful artificial ivory on the surface of photographic printing paper, by mixing together gelatine and oxide of zinc.

Gelatine, with white *papier maché* and rolled into sheets, forms also a good artificial ivory.

Ivory, Flexible. Ivory articles may be rendered flexible and semi-transparent by immersing them in a solution of pure phosphoric acid, sp. gr. 1·130, and leaving them till they lose their opacity. They are then washed with water, and dried, when they become as flexible as leather. They are hardened on exposure to dry air, but resume their flexibility on being immersed in hot water.

Ivory, Vegetable. The milk of the fruit of the *Phytelephas mucrocarpa*, which grows in Central America, hardens, and becomes like ivory. It is frequently used as a substitute for ivory in buttons and small turned articles.

Ivory Black. Ivory dust carefully calcined in a closed crucible.

Japan. Black japan for leather is made thus:—

1st Method.

Mix	Boiled linseed oil	1 gallon.
	Burnt umber	8 ounces.
	Asphaltum	3 ounces.

Boil together, and add sufficient oil of turpentine to give it the proper consistence.

2nd Method.

Mix	Oil of turpentine	2 ounces.
	Shellac	1 drachm.
	Alcohol	4 ounces.
	Lamp black	½ ounce.

Jew's Pitch. Bitumen Judaicus: Asphaltum; *q. v.*

Jeweller's Plate Powder. *See* "Rouge."

Jeweller's Putty. Tin putty, an oxide of tin, made by levi-

gating the crusts of oxide that form upon the metal when kept for some time in fusion. It is used for polishing hard bodies.

Juices of Plants. Papers stained with the juices of various plants are altered in colour by exposure to sunshine. Sir John Herschel, some years ago, communicated to the Royal Society the results of many interesting experiments made by him on the juices of plants. His method of proceeding was, to crush the petals of the flower to a pulp in a marble mortar, either alone, or with the addition of alcohol, and to express the juice by squeezing the pulp in a linen cloth; it was then spread upon paper with a flat brush, and allowed to dry spontaneously in the dark. The tint communicated to the paper is not always that of the petal of the flower. The most sensitive colour met with was that of the *Corchosus Japonica*, the yellow tint of which is speedily bleached by sunshine. Paper stained with the blue tincture of the double purple groundsel is completely bleached by light. The juice of the *Senecio splendidus* imparts a rich and deep velvety purple tint to paper, which is very insensitive to light.

We may add that the juice of the *Rhus striata*, of South America, and of the *Rhus venenata*, or poison-tree, of North America, both communicate indelible black stains to paper. The latter has been used for marking linen.

Among the juices of plants are many important dyes, such as indigo, madder, saffron, &c., &c., many of which are bleached more or less by light. In the case of indigo, however, the expressed juice from the leaf of the indigo plant is originally colourless, but is darkened to a deep purple tint by exposure to air and light. This dye is very permanent.

Kaolin. Porcelain clay, used for decolourizing discoloured nitrate baths, and other solutions. The best way of using it is to add a little to the solution, shake well up together several times, and then let it stand to settle; afterwards decant the clear liquid.

Kaolin is a fine pure white clay prepared by levigation from mouldering granite, and used for making vessels of porcelain. It contains nearly equal parts of alumina, or pure clay, and silica, together with about one per cent. of lime and oxide of iron. It is found in veins in primitive mountain districts, chiefly in China and Japan, Saxony, the neighbourhoods of Limoges and Bayonne in France, and in England in the counties of Devon and Cornwall.

Kaolin sometimes contains chalk, which renders it unfit for decolourizing acid solutions of nitrate of silver. This impurity may be

removed by treating the kaolin with a weak acid and subsequent washing.

Kelp. British barilla: the cinder ash obtained by burning various species of sea-weed, but chiefly the *Fucus vesiculosus*, or "bladder-wrack," and the *Fucus nodosus*, found on the western coasts of Ireland and Scotland. It is the principal source of iodine, and contains chiefly soda salts. Pearl-ash, or wood ashes, contains principally salts of potass. Soda was formerly obtained from kelp, and the manufacture of this substance was then extensively carried on by the inhabitants of the west coast of Scotland; but, since the method of obtaining soda from common salt has been introduced, the manufacture of kelp has greatly declined.

Kerosolene Coating Fluid. A solution of one grain of india-rubber to the ounce of kerosolene—a hydro-carbon resembling benzole in its properties, but much lighter, and a powerful anæsthetic. This solution is used in the dry collodion process, in order to make the film stick more firmly to the plate. *See* "Coating Fluid." Kerosolene is highly volatile, and the film of india-rubber, therefore, dries very quickly upon the glass; much more so than when benzole is used as the solvent.

Kreosote, Creasote. (Greek, κρεας, flesh; σωζω, to save.) This substance is obtained from the distillation of wood tar, by a troublesome process which need not be described in this work. It is a colourless, transparent liquid, of great refractive and dispersive power, having a caustic taste, and a strong odour resembling that of smoked meat. It combines readily with acetic acid and ammonia; and alcohol, ether, naphtha, and acetic ether dissolve it in all proportions. It dissolves many salts, also the resins, camphor, essential oils, and almost all vegetable colouring matters, and coagulates albumen and casein. It mixes sparingly with water.

The chief use of kreosote is derived from its powerful antiseptic properties. It prevents the putrefaction of animal and vegetable matters, and a drop or two may sometimes be added with advantage to solutions of gelatine, iodizing solutions for waxed paper, ink, &c., &c. A substance similar to kreosote is supposed to have been used by the ancient Egyptians for the purpose of embalming mummies.

Lac. A species of resin secreted from the puncture made by an insect called the *Coccus ficus*, in the branches of various plants which grow in the East Indies.

Lac is a very important article in manufactures, because not only

is the resin useful for making varnishes, sealing-wax, &c., but the colouring matter combined with it forms a magnificent red dye, which is extensively used as a substitute for cochineal. In consequence of the puncture of the insect, the twig of the plant becomes encrusted with a red resinous substance, sometimes as much as a quarter of an inch thick. These encrusted twigs are called "stick-lac." It contains about 7 per cent. of resin, and one twentieth part of that quantity of colouring matter. This valuable colouring matter is removed by pulverizing the stick-lac, and triturating it with water. What remains is called "seed-lac." In India this is put into oblong bags of cotton stuff, and a man at each end of the bag holds it over a charcoal fire. The liquefied resin drops through, and is received upon smooth stems of the banyan-tree; in this way it is formed in thin plates, and is called "shell-lac."

Shell-lac consists of two or more resins, one of which is soluble in all proportions in anhydrous alcohol, ether, and volatile and fat oils. The alcoholic solution is of a reddish colour, and forms an excellent spirit varnish in Photography. (*See* "Varnish.") Shell-lac may also be easily dissolved in dilute hydrochloric and acetic acids, and also in a solution of borax, with the aid of heat. Before dissolving it in alcohol, it should be very finely pulverized and exposed to the air for some months. Shell-lac may be bleached with chlorine, and then makes colourless varnishes. The bleaching is effected by first dissolving it in caustic potash, and then passing chlorine gas through the solution, after which it is pulled and washed in hot water, and twisted into sticks.

Shell-lac is much used in making sealing-wax.

Lac dye is made by evaporating to dryness the liquid in which the pounded crude lac is digested, and making the residue into cakes. This is soluble in dilute sulphuric or hydrochloric acid, and the mordant is protochloride of tin, and bi-tartrate of potash. It gives a fine scarlet colour.

Lacquer. A varnish composed chiefly of shell-lac dissolved in alcohol, and coloured with gamboge, dragon's blood, &c. The following is a good formula:—

Seed lac	120 parts.
Gamboge	120 „
Dragon's blood	120 „
Saffron	39 „
Rectified alcohol . . .	1000 „

Digest with heat, and strain.

The following is another formula in which turpentine is the solvent:—

Seed lac	120	parts.
Sandarach	120	,,
Dragon's blood . . .	15	,,
Tumeric	2	,,
Gamboge	2	,,
Venice turpentine . . .	60	,,
Spirits of turpentine . .	1000	,,

Digest with heat, and strain.

Lamp Black. A form of charcoal, obtained by burning the refuse resin left in the distillation of turpentine, and collecting the smoke in chambers hung with old sacking, upon which the soot is deposited. This is swept off from time to time, and is commercial lamp black.

When lamp black has been heated to redness, it is a very pure form of charcoal, and burns entirely away without leaving an ash. Its principal use is in the manufacture of printer's ink (*q. v.*). A black water-colour is made of it by mixing it with honey; and also Indian ink (*q. v.*). It will probably, before long, be used extensively in Photography in the process of printing in carbon.

Lamp black mixed with French polish is used by opticians for blackening the brass work of optical instruments; and mixed with size for blackening woodwork. These mixtures leave no gloss when dry.

Latent Heat; Latent Light. It is stated in the article on Light that both light and heat are certainly due to the undulations of an elastic ether which pervades space; and that the rays both of light and heat are propagated with enormous velocity, and can be refracted, reflected, polarized, &c., by similar means. We have suggested, therefore, that heat may be an undulation of the same universal ether as that in which light is propagated, the difference being that the waves of heat are longer than those of light. There is, however, this difference between light and heat, that whereas bodies when exposed to radiant heat become heated—that is to say, become themselves sources of radiant heat—bodies exposed to light do not in general become self-luminous, or sources of light (we say *in general*, because solar phosphori offer a few exceptions to the rule). This may be in consequence of the light received by bodies being converted › heat; the short waves of light which vibrate in the interstices of ›dy being lengthened into waves of heat by the mechanical effect he atoms of the body vibrating amongst them.

When a body is heated, it in general expands, and contracts on cooling; that is, radiates heat while returning to its former dimensions. It is in the highest degree probable that the sun once extended far beyond the limits of the planetary system, its temperature being then very little above that of space; that it gradually contracted in dimensions, and by so doing became a source of heat and light to the planets which were from time to time detached from it; that this contraction of volume may be still going on, while the amount of light and heat propagated by the condensation of the solar materials may be for ages to come continually on the increase, after which a reaction may occur similar to what has happened in the case of the earth, which was once in a fluid incandescent state, propagating light and heat into space by its contraction of volume, which volume at last attained a minimum, the surface of the globe cooled into a solid crust, and the earth became as we find it, non-luminous and opaque.

Matter, then, in motion can act upon *ether* and communicate vibrations to it; on the other hand, *ether* in motion can act upon *matter* and communicate vibrations to *it*, altering its form, volume, &c. Among these actions and reactions between gross matter and subtle ether we must endeavour to seek for an explanation of the phenomena due to the imponderable agents.

When a body is heated above the temperature of surrounding objects, it gradually cools until an equal temperature is obtained amongst them, in which state the atoms of ether pulsate in unison with those of the bodies.

Heated bodies do not all cool at the same rate. The time in which a body at a certain temperature cools, when suspended *in vacuo*, to a certain lower temperature, is called its "Specific Heat." The following table shows the specific heats of different bodies:—

Water	1000	Zinc	93
Sulphur	188	Silver	56
Glass	117	Mercury	33
Iron	110	Platinum	31
Copper	95	Lead	29

Experiments seem to indicate that the specifie heat of a body varies inversely as its atomic weight. For instance, the atomic weight of sulphur is 16, of lead 103·5; the specific heats of these substances being as 188 : 29; and the ratio of 29 : 188 being nearly equal to that of 16: 103.

Now we come to the particular subject of this article; viz., "Latent Heat."

Strong brine, *i.e.*, a saturated solution of common salt in water,

freezes at 0° of Fahrenheit's scale; water at 32°. Suppose then that two vessels, one containing water, the other brine, and each having a thermometer immersed in the liquid marking the temperature, say at 60°, are taken out-of-doors on a winter's day, when the temperature is 20°. The thermometers at once begin to fall; that in the brine goes on continually falling until it reaches 20°, while that in the water exhibits a curious phenomenon; it first sinks gradually until the water begins to freeze, then remains stationary until the *whole* of the water is congealed or crystallized into ice (or it may rise a little during the process), and afterwards goes on falling as before until the temperature of the ice becomes 20°. It remains, therefore, to explain this curious phenomenon, which accompanies the change of form of a body from the liquid to the solid state.

It has been supposed, we think erroneously, that water contains "latent heat," that is, material atoms of heat in chemical combination with it, and that these are given off during the process of congelation. This supposition of "latent heat" is evidently only tenable on a sort of *corpuscular* theory of heat; for, on the *undulatory* theory of heat, "latent heat" would be synonymous with latent motion, and the idea would involve a contradiction. There cannot be latent heat on the undulatory theory, and it remains for us to offer another explanation which shall be consistent with that theory.

The facts are simply these:—During the time which is occupied by the water in changing its form from the liquid to the solid state, it does not propagate any undulations of heat in the surrounding space, and thereby become colder. The propagation of undulations of heat by the action of the atoms of water upon those of the ether contained in it is for a time arrested. It is only necessary to state the fact in the above form. No further explanation is required.

Conversely: if a lump of Wenham Lake ice at a temperature of 10° be brought into a warm room, it does not begin to melt until the temperature has risen to 32°, and it remains stationary at that temperature until the *whole* of the ice is melted; the temperature of the water then begins to rise. The explanation is the same as before.

"Latent heat" may be a convenient term to employ, but the *facts* should not be misunderstood.

It would be out of place to pursue this subject further, but all the phenomena of latent heat may be explained in the way we have pointed out.

"Latent light" is another expression which has been adopted somewhat hastily in attempting to explain some phenomena of light

said to have been discovered by M. Niépce de St. Victor. Certain substances called "Solar phosphori" have the well-known property of becoming self-luminous by being exposed to light; just as a piece of slate has the property of becoming hot by being held before the fire. The piece of slate when removed from the fire radiates heat;—the solar phosphorus, when removed from the sunshine and taken into a dark room, radiates light. The two cases are strictly parallel. This property of solar phosphori has been long known, but M. Niépce states that he has discovered that white paper, and other substances, become *actinic*, after having been exposed to sunshine, and in this state react upon sensitive photographic tablets in the dark room. These substances have been said to absorb light by insolation, and retain it as "latent light" within their pores; but this explanation involves the same absurdity as the idea of "latent heat." The fact probably is, that the insolated substance does not convert the actinic rays into heat rays, as bodies mostly do, but propagates them unchanged, when taken into the dark, and thereby produces the effects due to actinism, when laid upon a sensitive photographic paper or plate. If we assume the statement of the fact to be correct, the experiment described by M. Niépce, in which light is supposed to be potted in a sealed cylinder, and liberated after any interval of time by removing the cover, may be explained thus:—

The inside of a hollow cylinder of tin is lined with paper which has been steeped in a solution of nitrate of uranium. It is then exposed to sunshine for some time, and sealed up. On removing the sealed cover, in the dark room, some months afterwards, and applying the open end of the cylinder to a piece of sensitive chloride paper, it is darkened all over; or if an engraving on India paper be laid upon it, so as to act as a negative placed between it and the contents of the tube, an image of the engraving is obtained. The explanation is, that the nitrate of uranium in the paper is deoxidised by light, and converted into a proto-nitrate of uranium. This becomes oxidised again in time, and converted into a per-salt, at the expense of the oxygen contained in the aqueous vapour in the tube, thereby liberating hydrogen, which darkens the chloride paper, or prints an image upon it through India paper.

To seal up *light* in a pot would be the same thing as to seal up *motion*, for light is motion. Such an idea is surely absurd.

Lavender Rays. The faintly luminous rays beyond the violet end of the spectrum are called "lavender rays." They are said to be highly actinic; but the maximum of actinic power lies probably

within the violet rays; this, however, may depend upon the nature of the substance acted on.

Lead. Pb = 103·5. This useful metal has been known from the earliest times, and was called by the alchemists "Saturn." It is found chiefly in the form of sulphide, or "galena." Pure lead may be obtained by heating oxalate of lead in a covered crucible. Lead may be rolled into sheets, and drawn into wire; it melts at 612°; and by the joint action of heat and air is easily oxidized, although at ordinary temperatures it undergoes but little change from exposure to air. When in a state of fine division it combines readily with oxygen, and takes fire in the air. When immersed in distilled water it takes oxygen from the air contained in the water, and the oxide formed being soluble to some extent in the water it becomes impregnated with oxide of lead. Hence arises the poisonous character of water which has been collected in a leaden cistern, or passed through leaden pipes.

Lead, Acetate of. $PbO, C_4 H_3 O_3 + 3 HO = 189{\cdot}5$. This substance may be prepared by dissolving litharge or protoxide of lead in acetic acid, to saturation. When added to the gallic acid developer for calotype negatives, it and some other salts of lead have a marked power in forwarding the development. The rationale of their action is not known, but the fact is fully substantiated.

Lead, Nitrate of. $PbO, NO_5 = 165{\cdot}5$. This salt is formed by dissolving either litharge or metallic lead in diluted nitric acid. On evaporation, the solution yields octohedra crystals, which are sometimes transparent, but more commonly white. In the gallic or pyrogallic acid developer it acts very much like the acetate previously described, but not so energetically.

Lead, Protoxide of, or Litharge. PbO = 111·5. The "galena," or native sulphide of lead, from which lead is commonly obtained, sometimes contains silver. When this is the case, a blast of hot air is passed over the fused mixed metals. This oxidises the lead, but has no effect upon the silver. The oxide of lead, or litharge, is therefore blown off, and collected in a suitable chamber.

Litharge is a heavy yellow powder, slightly soluble in water, to ·ch it gives an alkaline reaction. It melts at a red heat, and ls to crystallize on cooling, but on reaching 212° falls into a ·der. When melted, it combines energetically with siliceous er, and would destroy an earthen crucible.

itharge is much used by painters as a dryer. *See* "Linseed

Oil." Dark red litharge is called "litharge of gold;" the pale variety, "litharge of silver."

Water which has been filtered through litharge increases the energy of the developer which is dissolved in it; but this should be used immediately, for it will not keep. There is also danger of its producing fog upon the plate.

Leaden Pipes, Cisterns, &c. When pure rain-water is collected in leaden tanks, or passed through leaden pipes, the lead is oxidised by the air contained in the water, and a small quantity of the oxide formed is dissolved in the water, thereby communicating to it poisonous qualities. The same thing does not, however, happen to the same extent when river or spring waters, which contain in general certain soluble salts, are retained in leaden vessels, because then the surface of the lead soon becomes coated with an insoluble precipitate of sulphate, or carbonate, or phosphate of lead, which protects it from being further acted on by oxygen.

The presence of oxide of lead in the water used for photographic purposes may in some cases be rather beneficial than otherwise. For instance, in the pyrogallic developer, when freshly made, it would increase the energy of the development; but the developer would not keep; in a few hours, perhaps, it would become discoloured. Similarly, oxide of lead in the nitrate bath would perhaps increase the sensitiveness of the collodion film, but render the bath liable to "fog" the picture.

Lead may be easily detected in water, by tests which the photographer generally has at hand. Iodide of potassium would give a yellow tinge, sulphuric acid a white cloudiness, sulphide of ammonium a dark discoloration to water containing oxide of lead in quantity sufficient to render its presence sensibly injurious, or otherwise.

Any brass work in contact with lead would set up electric action, and assist the production of oxide of lead.

Bottles should not be made of flint glass, as some chemicals act on the lead which it contains. There is no lead in crown glass, and this should always be used for bottles intended to contain chemicals.

Achromatic lenses should never be exposed to the fumes which sometimes prevail in the laboratory, or dark room. The surface of the flint lens is frequently injured from this cause, and becomes iridescent.

Leather. An insoluble compound of tannin and gelatine. Tannin is a very delicate test of gelatine, and if added to water containing

the one five-thousandth part of gelatine it produces a cloudiness in it. It combines so energetically with gelatine, that if a piece of skin or bladder of sufficient size be suspended in a solution of tannin, the whole of it is in time abstracted from the water, and the skin becomes converted into leather.

In the manufacture of leather the skins of animals are first steeped in lime water, in order that the hair and cuticle may be more easily separated, and then softened by allowing them to enter into a certain state of putrefaction, or by the action of acids. They are then immersed in an infusion of oak bark, which contains tannin, and in time converts them into leather. The process is continued sometimes for several months, the infusion being renewed from time to time, and is not arrested until the entire substance of the skin has become brown throughout. Sometimes infusions of other astringent vegetables containing tannin, such as valonia, sumach, catechu, and the barks of the willow, birch, elm, and Spanish chestnut, are substituted for oak bark.

This is ordinary tanning; but there are other kinds of leather, as follow:

Tawed leather. An insoluble compound of gelatine and chloride of aluminium. The skin is first steeped in an alkaline liquor, then in a solution of alum and common salt, which react on each other and produce chloride of aluminium and sulphate of soda. White glove leather is prepared in this way.

Wash leather. The skin is prepared and softened in the usual way, then steeped in oil, and afterwards in an alkaline solution.

Curried leather. Common tanned leather, while still moist, is besmeared with oil, which, as the water evaporates, takes its place in the pores of the leather, and renders it waterproof. This is also called "upper leather."

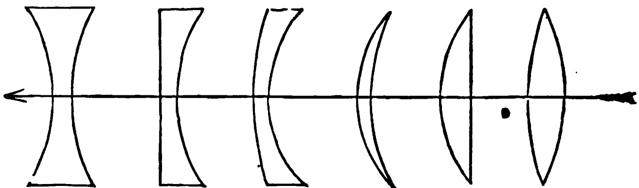
Leather Varnish. If a sheet of paper, or a positive on paper, be first immersed in a solution of gelatine, dried, and then steeped in a solution of tannic acid, the gelatine will be rendered insoluble, and converted into a species of leather varnish; and by repeating the operation several times a considerable glaze may be communicated to the paper. This varnish, by filling the pores of the paper and rendering it better able to resist the action of moisture and external agents, would no doubt tend to the preservation of the proof. Gallic acid has no such action upon gelatine, and must not be substituted for tannic by mistake.

emon Juice. This is added to the nitrate bath in the process rinting by development upon plain paper; *q. v.* It contains

about 6 per cent. of citric acid, some mucilage, and possibly a little oil of lemons; also a white, tasteless substance termed "hesperidin," which is soluble in 60 parts of hot water, and also in alcohol, and ether.

Lens. A lens is a transparent body constructed for the purpose either of concentrating or scattering rays of light transmitted through it.

Lenses are in general made of glass, and are ground with spherical surfaces; the axis of the lens being the line joining the centres of the spheres, and therefore a line with respect to which the lens is symmetrical.



6 5 4 3 2 1

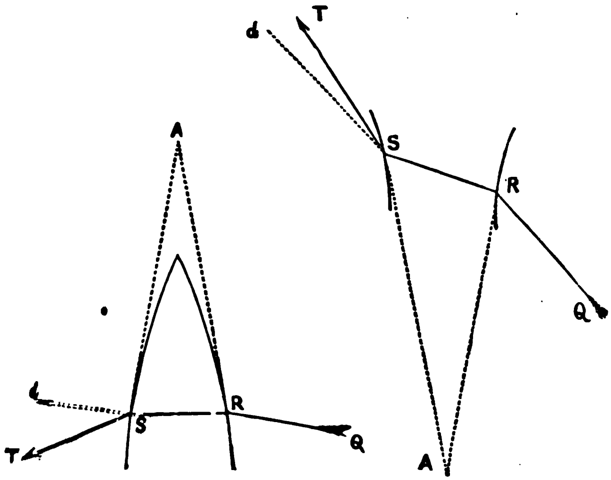
In the above figure six different forms of lenses are exhibited; and light is supposed to pass through them in the direction shown by the arrow.

No. 1 is called bi-convex; No. 2, plano-convex; Nos. 3 and 4, concavo-convex, or more frequently "meniscus;" No. 5, concavo-plane; No. 6, double concave. The nature of the surface upon which light is incident determines the first word of the compound appellative.

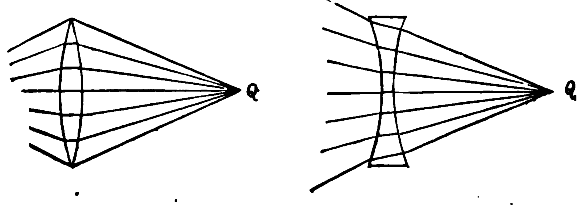
The first three lenses are thicker in the middle than at the edge, and are called "converging lenses," because they cause pencils that are refracted through them to *converge* more than they did before. Nos. 4, 5, 6, are thicker at the edge than in the middle, and are called "diverging lenses," because they cause pencils that are refracted through them to *diverge* more than before.

It has been shown in the article on the prism that when a ray of light is refracted through a prism it is turned, or caused to deviate, *from* the edge of the prism. Now we may suppose that the small portion of the spherical surface of a lens, on which a ray of light is incident, coincides with the tangent plane to the sphere at that point; and similarly with respect to that small portion of the opposite spherical surface from which the ray emerges.

If, then, QRST be a ray of light refracted through a lens, the small parts of the lens at R and S may be supposed to coincide with the tangent planes at those points, and these planes will in general



intersect, if produced, in a straight line, thereby forming a prism whose refracting angle is SAR. Now, if we draw Sd parallel to QR, the emergent ray ST will have its angle of deviation, dST, *from* the edge A of the prism, and will follow the course indicated in the figures. The mode in which a convex lens causes a pencil to converge, and a concave lens to diverge, will therefore be easily understood from the following figures, bearing in mind that the greater the angle of a prism may be, the greater is the deviation of a ray refracted through it.



No single lens is free either from spherical or chromatic aberration (*q. v.*). These errors are corrected by combining two or more lenses together. In a single convex lens, the surfaces of which have radii of different lengths, there is the least spherical aberration when the most convex side is presented to a cylindrical pencil. When the refractive index of the glass is 1·5, the radii of the surfaces should be as 1 : 6, and the most convex side presented to the origin of light. This lens has the least spherical aberration of all single lenses, and is called the "crossed lens." If we call the aberration of the crossed lens unity, the following table, calculated by Sir John Herschel, shows the aberration of some other forms of lens:—

Crossed lens	1·
Double convex / „ concave } equal radii	1·567
Plano-convex / „ concave }	1·081
Convex side turned to parallel rays.	
Plano-convex / „ concave }	4·2
Plane side turned to parallel rays.	

If two plano-convex lenses are placed with their convex sides in contact, and the focal length of the first be to that of the second as 1 : 2·3, the aberration will be only one fourth that of the single crossed lens.

Aberration may be entirely destroyed by placing a meniscus and convex lens with their centres in contact, according to the following table,—the convex lens being turned to parallel rays.

Focal length of convex lens	$-10{\cdot}000$
Radius of first surface	$-\ 5{\cdot}833$
„ second surface	$+35{\cdot}000$
Focal length of meniscus	$-\ 5{\cdot}497$
Radius of first surface	$-\ 2{\cdot}054$
„ second surface	$-\ 8{\cdot}128$
Focal length of compound lens	$-\ 3{\cdot}474$

In correcting for spherical aberration the *same* kind of glass may be used for both lenses, but when chromatic aberration is cured by combining lenses in contact, they must be made of *different* kinds of glass. The principle on which lenses are achromatized is explained in the article "Prism." It is only necessary to remark in this place that the formula by which the central pencil, refracted through a compound lens, is rendered achromatic does not also include the case of oblique and excentrical pencils, otherwise than as an approximation to the desired result.

Having thus briefly introduced the subject of lenses, we will proceed to describe more minutely the construction of those with which the photographer is principally concerned. They are as follows, viz.:—"Achromatic Meniscus," "Orthoscopic," "Globe," "Doublet," "Triplet," "Periscopic," "Panoramic," "Portrait Lens."

The first seven in the above list are intended for taking views; and the doublet and triplet are for copying purposes also. The portrait lens is either for taking portraits, or instantaneous views which include but a small angle, or for the purpose of enlarging by means of a solar camera.

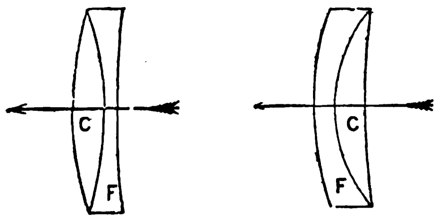
Achromatic Meniscus.

This is a lens composed of two elements; viz., a concave lens of flint glass, and a convex lens of crown glass, cemented together with Canada-balsam, and having its hollow side turned towards the view, with a diaphragm placed at some distance in front of it.

There are *three* forms of achromatic meniscus in common use; viz., two in which the front surface is nearly flat, and one in which it forms a deep hollow. The latter form is correct, and the others have been a mistake, although largely employed by photographers until within the last year or two. The superiority of the deep meniscus consists in giving a very much wider field of view, much better marginal definition, and less distortion of the image than the other forms having a flatter front surface. The front lens of Mr. Ross's doublet is the best example of the deep meniscus,—much better, for instance, than that which has been recently patented by Mr. J. H. Dallmeyer,—and in it the interior surface common to the two lenses is very nearly flat. The only objection to this very simple form of view-lens is, that the image is still subject to barrel-shaped distortion.

The two other forms of achromatic meniscus, having a nearly flat front surface, are shown in the following figures — the letters C and F denoting crown and flint glass respectively. That in which the flint glass receives the incident rays is the better form of the two. The second form, it would appear, was tried and condemned by the late Mr. Andrew Ross five-and-twenty years ago, but was patented in 1858 by Mr. Thomas Grubb, of Dublin, as a valuable novelty, although it had been known to opticians ever since the time of the elder Dolland, and had been described in an optical treatise published by Messrs. Horne and Thornthwaite in 1845. The name given to this patent lens by Mr. Grubb is APLANATIC, although there is not the slightest foundation in fact for such a term.

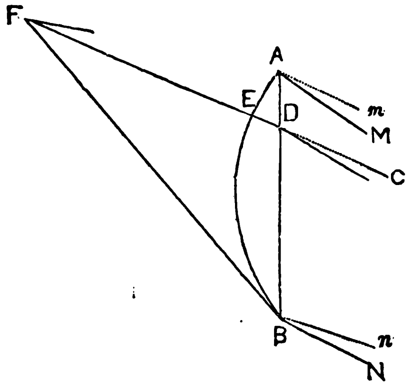
When the focal length of the achromatized lens, the radius of the front surface, and the materials used are the same, the focal lengths



of the crown lenses are the same in both cases, and also the focal lengths of the flint lenses; the radius of the posterior surface is also the same in both cases.

The principle of this form of lens will be best understood by discussing, in the first place, the case of a single plano-convex lens, with a stop in front.

Let AB be a plano-convex lens, presented to objects at such a distance that pencils from them may be considered cylindrical; and suppose an oblique cylinder of rays, MANB, from one of these distant points not situated upon the axis of the lens to be incident upon the plane side of it. Every ray of this large cylindrical pencil then suffers the same amount of refraction on entering the lens, and the pencil within the glass is a cylinder having its rays parallel to *m*A or *n*B. We have now done with the plane surface, and the case becomes simply that of a cylindrical pencil within a sphere about to emerge. It remains to be seen what becomes of it.



One of its rays, DE, if produced backwards, passes through the centre, C, of the spherical surface. This ray does not suffer deviation at emergence, but proceeds in the same straight line, DE, produced to F. Rays emerging at an equal distance from E cut the line DF in the same point and have equal aberration, and the caustic surface is symmetrical with respect to EF, which is therefore its axis; and EF is equal to the principal focal length of the lens for a direct pencil.

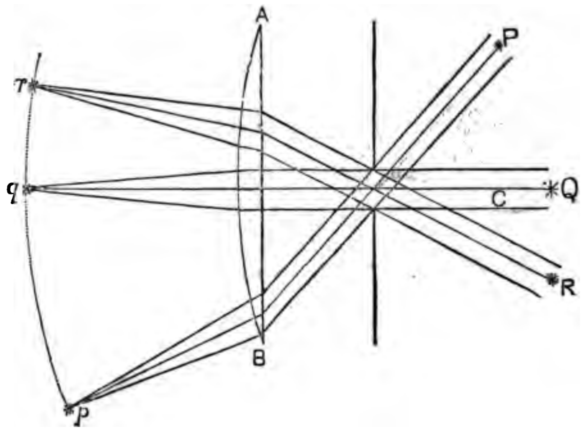
It appears therefore that EF is a constant quantity, not dependent on the obliquity of the pencil; CE is also a constant quantity, being the radius of the spherical surface AB; therefore CF is a constant quantity.

Hence it follows that when a plano-convex lens is directed to extremely distant objects, the image lies upon a spherical surface which has the same centre as the posterior surface of the lens.

This will perhaps be understood better by reference to the following figure.

AB is the lens; C, the centre of the sphere AB; P, Q, R, fixed stars emitting cylindrical pencils of light; QC*q*, the axis of the lens; and *p*, *q*, *r*, the images of the stars, which lie on the spherical surface shown by the dotted line, and the centre of which is C.

The stop is placed, as shown in the figure, for the purpose of cutting off the outside rays of the pencils, and thereby reducing the amount of spherical aberration in each pencil. It will easily be seen that the position of the stop for any particular pencil depends



upon its obliquity; and that the *greater* the obliquity the *nearer* the stop must be placed to the lens.

It will be seen by the foregoing figure that the amount of light in the image depends not only on the size of the stop, but also on the obliquity of the pencil, being greatest in the case of the direct pencil, and diminishing as the obliquity increases. For this reason there is not in the common view-lens absolute equality of illumination, the centre of the field having the most light and the edges the least.

From the case of the single plano-convex lens the transition is easy to that of the same lens achromatized, and thence to the achromatic meniscus. In these two latter cases it may be considered as approximately true that the field for distant objects is a sphere concentric with the posterior convex surface of the lens.

If the stop be placed immediately in contact with the lens, the radius of the field is shortened. There would, however, be no *distortion* in this case; while there is considerable distortion when the stop is put at a distance from the lens, in order to get a flatter field. *See* "Distortion."

The general form and principle of the common view-lens having now been described, it remains to give the exact formula for its construction.

The data are:—1st, the focal length of the lens; 2nd, the indices of refraction for the crown and flint glasses; 3rd, the dispersive powers of the glasses; and 4th, the radius of the front surface. Let these quantities be expressed by the following symbols:—

F = focal length of compound lens.
μ_1 = refractive index of flint glass.
μ_2 = " " crown glass.
D = ratio of dispersive power of front glass to back glass.
R = radius of anterior surface of lens.

The unknown quantities are:—

s = radius of inner surface of lens.
t = " posterior surface of back lens.
f_1 = focal length of front lens.
f_2 = " back lens.

Then the equations which connect these quantities are—

$$\frac{1}{f_1}+\frac{1}{f_2}=-\frac{1}{F} \quad . \quad . \ (1) \qquad \frac{f_1}{f_2}=-D \quad . \quad . \quad . \ (2)$$

$$\frac{1}{f_1}=(\mu_1-1)\left(\frac{1}{R}-\frac{1}{s}\right) . \ (3) \qquad \frac{1}{f_2}=(\mu_2-1)\left(\frac{1}{s}-\frac{1}{t}\right) \quad . \ . \ (4)$$

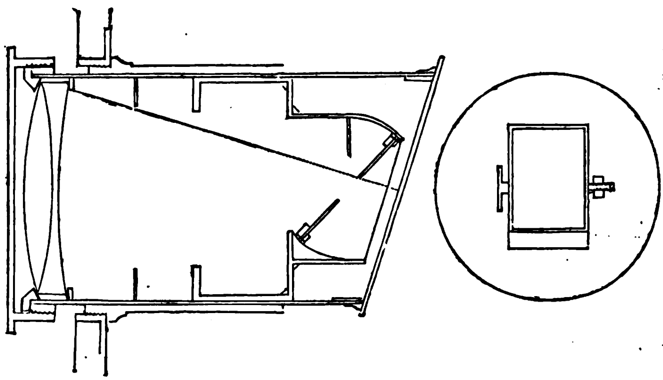
N 2

By which four equations the four unknown quantities may be determined.

It is immaterial in the above formula whether the flint or crown lens be placed in front, so as to receive the incident rays. If the flint lens be placed in front, the formula gives the common view-lens which has been in use for a number of years. If the crown lens be placed in front, the formula gives the lens shown by the second of the figures at top of p. 177.

The second equation must be fulfilled in order that the lens may be achromatic. No attempt is made to cure spherical aberration except by the stop. The central pencil from Q would have a finer focus, *q*, if the small central portion of the lens through which it passes could be turned with its convex side to the incident rays. See what has been said before respecting the aberration of a plano-convex lens. The remark is equally applicable to the compound lens, which is nearly plano-convex. The large lens of an opera-glass, which is compound and convexo-plane, is placed with the *convex* side to the objects; and for the same reason the front lens of the portrait combination has its *convex* side to the objects.

It now only remains to discuss the best mode of mounting the view-lens. This is shown in the following figure :—



The lens is placed in the tube with its concave side to the stop. A ring is then laid against the convex side, and it is screwed tightly 'ts place. The tube works in a jacket, which is screwed into a e in the front of the camera; the open end of it is closed by).; and for better security to the lens a cap is also screwed on 'e other end, when the instrument is packed for travelling,

Within the tube, a little in front of the lens, is a fixed diaphragm; and in front of that a moveable tube which carries the front diaphragm, which can be so adjusted as to revolve within a projecting box, in order that its full aperture may be presented perpendicularly to the darkest part of the picture, and its edge, so to speak, towards the sky, or lightest objects; and at the same time any one of a set of stops of different sizes may be introduced as circumstances require. This contrivance is sufficiently explained by the figure. As the tube can be turned in the jacket, the plane of the stop, when placed obliquely to the axis of the lens, can be brought into any required position. The front part of the revolving disc which carries the stop has a groove at the bottom and on both sides; and the stop, which is an oblong disc with a round hole in the middle, is slid into this groove like the lid of a box.

It will be seen that an annulus of the circumference of the lens is sacrificed; the lens must therefore be made so much larger as to allow for this. The object of this sacrifice of glass is to prevent the reflection of light from the broad edge of the lens. In the common mode of mounting the view-lens this edge forms a broad luminous ring, which is seen on looking into the camera at the open end; and of course the light which enters the eye from this ring would fall upon a sensitive plate if put in the same position.

The diaphragms within the lens-tube entirely prevent the reflection of light from the inside of the tube. A strip of black cotton velvet should be wound round the edge of the lens before putting it into its cell; and both the inside of the tube and diaphragms should be blackened with a mixture of lamp black and spirit varnish. There are times when it is convenient to be able to push the diaphragm nearer to the lens, and no mounting is complete which does not admit of this being done when necessary.

When a very small stop is used, the diameter of the circular space covered by the lens with good detail is nearly equal to its focal length.

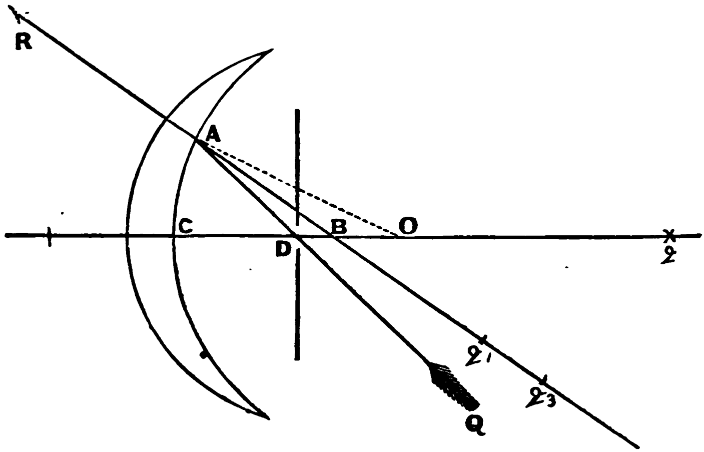
Distant objects have a shorter focus than near ones. If f be the principal focal length of the lens, u the distance of an object from it, and v the focal length of the lens for the distance u, then v is determined by the following equation:—

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

By means of a small stop, objects at different distances from the lens may all be brought into tolerably good focus upon a flat focusing screen.

Deep Meniscus.

When the front surface of the achromatic meniscus is made very deep instead of being nearly flat, as in the cases just discussed, it is possible to render the image of distant objects absolutely devoid of curvature. This very singular and unexpected property of the deep meniscus was discovered by Mr. Sutton about two years ago; and the following demonstration of it was given by him in *Photographic Notes* of February 1st, 1865.



The above figure represents a single uncorrected deep meniscus lens, AC, of which Cq is the axis, O the centre of the front surface, B the centre of the back surface.

The hollow surface is presented to the objects, and light is supposed to pass from right to left, as in all Cambridge optical treatises. The radii of the two surfaces, as well as the lines Cq, Aq_1, Aq_3, will, therefore, be affected by the sign plus.

The stop is placed at D, so that the extreme oblique pencil QDA may, after refraction, have its new direction AR, when produced backwards, pass through B, the centre of the back surface. The incidence, ·refore, of the refracted pencil upon the back surface of the lens is ·ct, and has no obliquity.

The angle of incidence of the extreme oblique pencil at the front face is QAO, and the angle of refraction BAO.

·ding to the usual notation, let the angle $QAO=\phi$;

BAO$= \phi'$ OC=OA=r; and let μ be the refractive index from air into glass.

Now when a pencil of parallel rays is incident upon a hollow surface, such as we are considering, the pencil becomes divergent within the glass. When direct and axial, its geometrical focus is at q; when oblique, its primary focal line is q_1, and its secondary focal line q_3. We are going to prove in what follows that q_1 is nearer to the point A than q_3; and also that Aq_3 is less than Cq. Consequently the oblique pencil will be more divergent within the glass than the direct axial pencil; and after emergence the oblique pencil will therefore have its focus (or circle of least confusion) further from the lens than the geometrical focus of the direct axial pencil, so as in fact to flatten the field.

Using the common notation, and bearing in mind that our pencils are small cylinders, the formula for the direct axial pencil becomes

$$\frac{\mu}{Cq} = \frac{\mu - 1}{r} \quad . \quad . \quad . \quad . \ (1)$$

and the formulæ for the oblique pencil become

$$\frac{\mu}{Aq_2} = \frac{\mu \cos \phi' - \cos \phi}{r} \ . \ (2)$$

$$\frac{\mu \cos^2 \phi'}{Aq_1} = \frac{\mu \cos \phi' - \cos \phi}{r} \ . \ (3)$$

We have to ascertain first whether Cq is greater, equal, or less than Aq_3; and next, whether Aq_1 is greater, equal, or less than Aq_3; bearing in mind that $\sin \phi = \mu \sin \phi'$

First, let us compare the equations (1) and (2) in order to see which is the greater, Cq or Aq_3. This will be ascertained by comparing the second member of equation (1) with the second member of equation (2); or, which is the same thing, by comparing the respective numerators of those fractions. Now it appears that

$\mu \cos \phi' - \phi$ is greater, equal, or less than $\mu - 1$

according as $1 - \cos \phi \quad . \quad . \quad . \ \mu (1 - \cos \phi')$

" $\quad 2 \sin^2 \frac{\phi}{2} \quad . \quad . \quad . \ 2 \frac{\sin \phi}{\sin \phi'} \sin^2 \frac{\phi'}{2}$

" $\quad \tan \frac{\phi}{2} \quad . \quad . \quad . \quad . \quad \tan \frac{\phi'}{2}$

But the first member of this inequality is greater than the second; therefore, by comparing equations (1) and (2) it will be seen that Cq is greater than Aq_3.

Again, by comparing equations (2) and (3), it is evident, on inspection, that Aq_3 is greater that Aq_1; because the second term of these equations is the same in both, and the cosine of an angle is always less than unity.

Hence it appears that the axial pencil within the glass diverges from a point q which is further from C than either of the focal lines q_1 or q_3 of the oblique pencil from A. The oblique pencil has, therefore, greater divergency when passing through the interior of the lens than the axial pencil; and, since the incidences of both pencils upon the back surface of the lens are direct, it follows that the image of the extreme marginal object of the view will be formed at a greater distance from the marginal part of the lens than the image of the central object of the view from the centre of the lens. So that by giving a suitable concavity to the front surface, and putting the stop in the right place, the field for distant objects may be rendered absolutely flat.

Observe further that the quantity by which Aq_3 is less than Cq depends upon the magnitude of r; and that it becomes greater as r becomes less. Hence the more hollow we make the front surface the flatter the field becomes, until at last it may be turned inside out and rendered convex to the lens instead of concave.

In the image formed by the deep meniscus lens, the primary focal line of the oblique pencil is *farther* from the lens than the secondary focal line; whereas, in the common form of meniscus view lens, the secondary focal line is farthest from the lens. This is a very important difference, and greatly in favour of good marginal definition in the deep meniscus lens.

The amount of hollowness which should be given to the front surface, in order to render the image quite flat, is such as would yield a flat interior surface between the lenses of the achromatic compound. At any rate, this is approximately true.

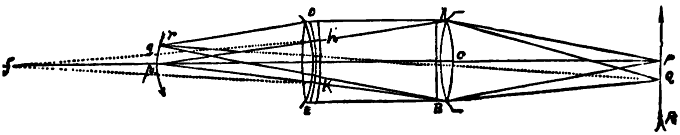
The front lens of Mr. Ross's doublet, reversed, and used with a stop in front, makes the best deep meniscus with which we are acquainted. It includes an enormous field of view.

M. Petzval's Portrait Combination.

The object of this instrument is to obtain an image well defined in its principal parts, *when a large volume of light is admitted.* In taking a portrait it is evident that the time of exposure should be reduced as much as possible, because, after remaining in a constrained position for

a long time, the features of the sitter betray an expression of the discomfort felt. A lens of large aperture must therefore be employed in portraiture, so long as photographic processes remain in their present state of insensitiveness. As soon, however, as the chemist shall discover the means of rendering these processes more sensitive, the optician will be released in a corresponding degree from the necessity of constructing lenses of large aperture; and the defects to which such lenses are liable, and which admit of no remedy, will be avoided by using smaller apertures. The nature of the defects of large lenses has, however, been misunderstood and exaggerated by persons ignorant of mathematics.

The portrait combination of Professor Petzval is that which has been generally adopted by opticians, and the arrangement of the lenses is exhibited in the following figure:—



The front lens A, B, is a compound lens, like the common view-lens, but placed with its *convex* side to the objects. It is achromatic, but not entirely aplanatic; this defect being remedied by the posterior lens.

The posterior lens is composed of two lenses separated by a small space; that next the front lens is of flint glass, convexo-concave, and *divergent*, being thinner in the middle than at the edges; the other is biconvex, and of crown glass, being placed with its most convex side next to the concavity of the flint, as shown in the figure. The posterior compound lens is achromatic, and the object of separating the lenses and giving them curves so different from that of the front lens is to cure *spherical aberration* in the entire combination.

Both lenses are therefore convergent, and the effect of the posterior lens is to shorten the focus of the front lens. It may be well to observe in this place that when a *con*vergent lens is rendered achromatic by combining two lenses of different kinds of glass, the concave lens must be of flint, and the convex lens of crown glass. On the other hand, when a *di*vergent lens is achromatized, the concave lens must be of crown, and the convex lens of flint glass.

The curves depend entirely on the refractive and dispersive powers of the glass used, and these vary with every "pot of metal."

To return to the figure.

Let PQR be an object placed before the lens, P being a bright point upon its axis. A direct pencil from P covers the entire surface, AB, of the front lens, and is refracted by it towards a point *f*. This converging pencil A*f*B is incident upon the portion *hk* of the posterior lens, and is by it refracted to a point *p*, at which the image of P is formed. It will be observed that *hpk* is a cone of light having a very large vertical angle *hpk;* both spherical and chromatic aberration must therefore be accurately corrected in such a pencil, and the focusing screen placed accurately at *p*, or the indistinctness of the image would be considerable. The optician has therefore greater difficulties to encounter in the construction of the portrait lens than in that for views.

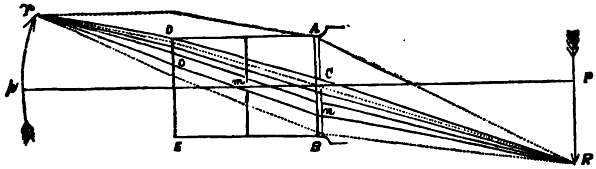
We have next to consider the case of an oblique pencil.

The central pencil does not cover the whole of the back lens, (which is the same size as the front lens), but merely the central portion, *hk*. The angle DA*h* is about equal to 3°. If therefore an oblique pencil, as QAB, makes an angle QCP of about 3°. with the axis of the lens, the upper ray of the refracted pencil will run along the tube AD, and the whole pencil will come to a focus at *q*. The image therefore between *p* and *q* will be equally illuminated. But if a more oblique pencil, as that from R, be incident on the lens, only a portion of the refracted pencil can pass through the back lens, the remainder of it being cut off by the upper part of the tube, which reflects it. This is one of the great defects of the portrait lens, and the mode of mounting it. Sometimes the back lens is made a little larger than the front lens, and then the equality of illumination extends over a greater space, but the outer portion of a *large* back lens does not perfectly cure spherical and chromatic aberration, and from this cause, indistinctness is introduced. The fact is, the portrait lens with full aperture has many serious defects, and the sooner photographers are enabled to give up using it the better. It should never be used from choice, but only from necessity.

The field of a portrait lens is not nearly so flat as that of a view lens of equivalent focus; and the angle of view properly included by a portrait lens is much narrower.

When the light is sufficiently good, a stop may be used with a portrait lens; and the question has arisen as to which is the proper place for it—in *front* of the front lens, or *between* the lenses. This question we will discuss with the help of the following figure:—

The lenses are represented by the lines AB, DE, as before. R is the origin of an oblique pencil, the axis of which, RC, makes the



same angle with the axis of the lens, as if it were the extreme oblique pencil of a view-lens; *i.e.*, PR is about equal to one-third of PC. Now CA is equal to one-third of AD, and the line RC suffers little or no refraction on passing through the front lens; therefore the axis of the refracted pencil between the lenses passes very nearly through D, as shown in the figure.

Now we may suppose that a whole pencil, RAB, comes accurately to a focus at *r*, for if it does not, the lens is worthless, inasmuch as it *ought* to cure spherical aberration in the oblique, as well as in the central pencils, when the focus is merely examined by unassisted vision. We may assume therefore that every ray of the pencil RAB which really passes through the back lens passes also through *r*. This being understood, it follows that by placing a stop midway between the lenses, at *m*, a small excentrical portion, R*n*, of the large pencil RAB is incident at *n*, passes through the stop at *m*, the back lens at *o*, and then comes to a focus at *r*; while if a small stop is placed at *c*, the *central* portion of the large pencil RAB passes through it, then through the back lens at D, and thence, as before, to *r*.

When, therefore, a *very small* stop is used, it scarcely matters whether it be placed at *c* or *m*; but if a *larger* stop be used, it would obviously be better placed at *m*, because, if placed at *c*, a portion of the rays of the refracted pencil would be cut off by the tube, and there would not be equality of illumination in the image. It must be remembered, however, that the focus at *r* is not *absolutely* perfect, and that the rays incident at C go to *r* with less spherical aberration than those incident at *n*.

There is, however, another point to consider in reference to the proper position of the stop in a portrait lens,—and that is, its influence on distortion. In consequence of the curvature of the image, the point *r* does not lie upon the plane of the picture, but in front of it; and the indistinct image of R which *is* formed upon the plane of the picture will be nearer to the centre of the picture when

the stop is at C than when it is at *m*. There is consequently barrel-shaped distortion when the stop is placed in front of the lens; whilst by assigning to it a proper place between the lenses distortion may be altogether avoided. This is a great argument in favour of placing the stop between the lenses. If the image were received upon a glass having the same curvative as *pr*, it would be a matter almost of indifference whether the stop were placed at *c* or at *m*.

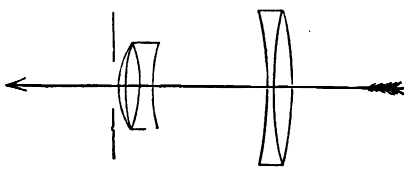
But a portrait lens is not intended to be used with a small stop. When a small quantity of light will do the work required, it is far better to use a view-lens. Nevertheless, stereoscopic pictures are sometimes required to be taken instantaneously, and sometimes with the ordinary exposure for views; in this case a pair of small portrait lenses, furnished with stops, will answer both purposes, inasmuch as stereoscopic pictures need not include so wide a field as ordinary views.

A portrait lens, therefore, is only intended to be used for subjects which must be taken quickly, or instantaneously. It does not give so flat a field as a view-lens; nor does it give equality of illumination; nor can objects at different distances be all brought into good focus; nor does it include a wide angular field.

The Orthoscopic Lens.

The term "orthoscopic" is derived from the Greek words ορθος, right, and σκοπεω, I see. The meaning is, that the lens gives images more free from distortion than the other lenses which were in use before its introduction.

The orthoscopic lens is an arrangement consisting of two achromatic compound lenses, separated by an interval, as shown in the figure.



The front lens is the larger, and is the same as the front lens of the present combination for portraits; that is to say, it is composed of a double convex lens of crown glass, cemented with Canada balsam to a concave lens of flint, the entire lens having *negative* focal length—that is, causing parallel rays to converge to a focus on the *opposite* side of the lens to the origin of light.

The posterior lens is an achromatic compound lens formed of two,

not cemented together, but merely touching at the edges, and having a space between them in the middle, as shown in the figure. The inner lens is of crown glass, and double concave, the flatter side being next to the front lens. The outer lens is a meniscus of flint glass, having its convex side outwards and next to the picture. The deepest concavity of the crown lens is therefore opposite to the concavity of the meniscus. As these lenses are not cemented together, but have a cavity between them, their inner surfaces may sometimes require wiping; they are therefore merely deposited in the cell which receives them, and are fixed in their place by a counter-cell which is screwed until it touches a brass ring laid in contact with the outer lens. When a stop is used, it is placed between the ring and the counter-cell, as shown in the figure. The diameter of the posterior lens is about two-thirds that of the front lens, and the distance between them is about half the diameter of the front lens.

The posterior compound lens has *positive* focal length, and would cause parallel rays to *diverge* from a point on the *same* side of the lens as the origin of light. The front lens therefore tends to bring parallel rays to a focus, the back lens to scatter them wider apart. In popular language, the front lens is convex and magnifies, the back lens is concave and diminishes.

We would take this opportunity of observing that in optics the signs *plus* and *minus* are introduced into formulæ from their property of being able to represent, not merely the operations of addition and subtraction, but also contrariety of position or direction. By calling lines measured on one side of a lens positive, and on the other side negative, and affixing the signs *plus* or *minus* to the magnitude of a line, according to its position, it is possible to make one formula include a great variety of different cases. The convention adopted in optics is, to call lines measured from the lens *towards* the origin of light *positive*, and in the opposite direction *negative*. In other branches of mathematics it is found very convenient to adopt similar conventions, in which the signs *plus* and *minus* indicate *opposite qualities*, as well as mere addition and subtraction.

More exact particulars of the compound lenses are as follows:—

Front lens—Diameter	. . .	8 centimètres		
Focal length	. . .	40	do.	(Negative)
Back lens—Diameter	. . .	5 centimètres.		
Focal length	. . .	90	do.	(Positive)
Distance between the lenses 4 centimètres.				
Focal length of entire combination	.	63	do.	(Negative)
Diameter of the field	. . . .	54	do.	

[A centimètre is about two-fifths of an inch.]

These dimensions apply to the 3-inch lens, as made by M. Voigtlander; but, by dividing or multiplying them all by any given quantity, the corresponding dimensions of any other size of lens may be obtained.

The front lens is placed with its convex side to the view, and the back lens with its convex side to the picture.

Since the front lens of this new instrument is the same in every respect as the front lens of the portrait combination, the latter may be converted into the former by removing its posterior lens, and substituting for it the posterior lens of the orthoscopic combination, mounted, of course, at its proper distance from the front lens.

In order to cut off reflected light from the inside of the tube, a stop is placed midway between the front and back lens; but not so as to intercept any of the legitimate rays of light.

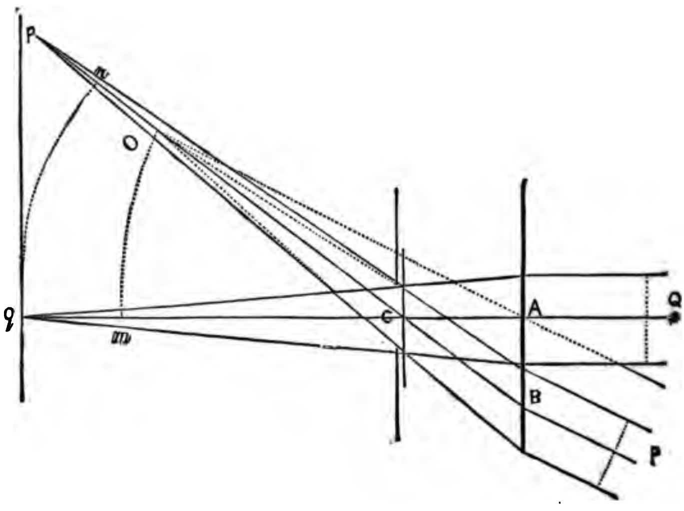
Such is the construction of the orthoscopic lens. It is essentially a VIEW-LENS, and is not intended for portraiture. We have, therefore, to discuss its merits as a view-lens when compared with the meniscus form, and in doing so must direct our attention more particularly to the following points:—

1st,—Flatness of field, and the included angle of view.

2nd,—Freedom from distortion.

3rd,—Equality of illumination.

4th,—Perfection of focus, and freedom from spherical aberration.



5th,—Coincidence of the visual and actinic foci.

6th,—General convenience, freedom from diffused light, copying powers when the focus is elongated, power of rendering aerial perspective, and other good qualities.

We shall discuss these matters in the order in which they stand.

1st,—Flatness of field, and the included angle of view.

In determining the flatness of field of any lens, we have to compare the course of the most oblique with that of a direct pencil; and the simplest plan is to suppose the pencils cylindrical, or that the lens is pointed at extremely distant objects; should it be found to answer well in this case, it will be equally good for all ordinary purposes.

In the above figure the lenses are represented by straight lines strong and black, the front lens passing through A and the back lens through C; ACq being their common axis. A stop is placed behind the back lens, and in contact with it. In order to fix the ideas, and render what we have to say more intelligible, we shall suppose the lens to be a No. 1, having a combined focus of rather more than 11 inches, and covering a picture 10×8, with a half-inch stop.

It will be seen, from the above figure, that the oblique pencil passes *ex*centrically through the front lens and *cen*trically through the back lens. If, then, q be the focus of the direct pencil from a distant point Q, and p the focus of an oblique pencil from a distant point P, we have to compare the length Cp with Cq, in order to discover the flatness of field, and how far it deviates from a sphere whose centre is C; and we would observe that unless it *does* deviate, and that pretty considerably, from such a sphere, the lens would be next to worthless for the purpose intended. We have to show, then, that the focal length, Cp, of the oblique pencil is greater than the focal length, Cq, of the direct pencil, and to calculate the difference between them.

Let us consider first the case of the direct pencil incident at A. After refraction through the front lens, it converges towards m, the principal focus of that lens; the distance Am being 8 inches (in round numbers). This converging pencil is then refracted by the posterior lens, the positive focal length of which is 18 inches (in round numbers). The effect of this is to diminish the convergency of the rays, and bring them to a focus at q, which is further than m from C. The distance AC being one inch, Cm is 7 inches, and Cq is then found in the following way:—

Multiply 7 by 18, and divide the product by their difference; that is, divide 126 by 11. This gives $Cq = 11\frac{5}{11}$ inches.

Next, let us consider the oblique pencil which proceeds from a distant point, P, is incident *excentrically* on the front lens at B, and passes centrically through the back lens at C.

Through A, the centre of the front lens, draw a dotted line AO, parallel to BP, and with A as centre, and A*m* as radius, strike an arc of a circle cutting AO at O. Then AO equals 8 inches; and the oblique pencil at P will, after passing through the front lens, converge towards the point O (as shown by the dotted lines).

Now we come to the pith of the matter. What happens at the second lens?

We have at the second lens an oblique pencil, incident centrically, and converging towards O. Join therefore CO, and produce it to *p*. Also, with C as centre and C*q* as radius, strike a circle cutting C*p* at *n*. C*n* is therefore equal to C*q*.

Now, adopting the same formula as in the former case in order to find C*p*, we must multiply CO by 18 and divide the product by their difference. What then is the length of CO?

In the reply to this query will be seen the value of M. Petzval's arrangement; for it appears that CO is greater than C*m*.

The proof of this is easy enough. Any two sides of a triangle are, together, greater than the third; therefore OC and CA are together greater than AO, and therefore than A*m*. Take away the common part AC, and CO is proved to be greater than C*m*.

The actual difference between CO and C*m* in the No. 1 lens, with the extreme oblique pencil, is about the one-tenth of an inch. If, then, we multiply $7\frac{1}{10}$ by 18, and divide the product by their difference, we get $Cp = 11\frac{79}{109}$ ins. The difference between C*o* and C*m* (*np*) is therefore nearly one-third of an inch. This is, of course, in favour of flatness of field, because it brings *p* nearer to the plane through *q*.

But another circumstance still more favourable to flatness of field proceeds from the fact that the back lens of the combination, which is a powerful concave, has a great effect in lengthening the focus of the oblique pencils. By adjusting the power of this lens, the optician has, therefore, perfect control over the flatness of field; and he can render the image of distant objects quite flat if he chooses.

We now come to the 2nd topic; viz., Freedom from distortion.

n the common view-lens with the stop in front, the oblique pen- do not pass straight through the margin of the lens, but are bent of their course, inwards, towards the centre of the picture. produces distortion, in a way in which we will endeavour to in. Suppose the stop extremely small, and the lens removed; spective view would then be formed on the focusing screen,

but larger than the picture produced by the lens, and quite free from distortion. Suppose a plain irregular polygon to be the figure represented, the angles of which on the focusing screen are points A, B, C, D, &c., and let O be the point where the axis of the camera cuts it. Draw radial lines OA, OB, OC, OD, &c. Now introduce the lens. In consequence of the deflection of the axes of the pencils which pass through the margin of it, towards the point O, the image of the polygon will be smaller than before, and its angular points *a*, *b*, *c*, *d*, &c., will lie on the lines OA, OK, OC, &c., nearer to O. Now, if the decrements *a*A, *b*B, *c*C, &c., were exactly proportional to the radial lines OA, OB, OC, &c., the small polygon *abcd* would be exactly similar to the large one ABCD—and there would be no distortion; but no such law is observed in the production of these decrements as that of direct proportionality to the radial line. This produces distortion, and causes all straight lines which do not pass through the centre of the picture to be bent inwards at their extremities. *See* "Distortion."

Now let us turn to the orthoscopic lens. Here we see that the axes of the oblique pencils are bent *outwards* out of their course, and a *larger* picture produced than if a small hole, without lenses, were put at C. Instead of *de*crements we have now *in*crements of the radial lines—and the production of these increments depends upon a different law from that of the decrements in the former case. What distortion there is, has the effect of rendering straight lines *convex* to the centre of the picture, by bending their extremities outwards.

3rd,—Equality of illumination. Through *m* imagine a line *mk* drawn at right angles to *m*C, and cutting C*p* in *k*. Now let a straight line, passing always through this imaginary point *k*, sweep round the circumference of the stop at C and mark out with its end a circle on the front lens, in the neighbourhood of B, which would be its centre. Similarly, let a line passing through *m* sweep round the circumference of the stop and trace another circle on the front lens, the centre of which would be A. These two circles, viz., that at A and that at B, will be equal to one another. But if, instead of the point *k*, we take the point O, nearer to C, the circle at B will then become *larger* than before, and consequently larger than that at A. Hence it follows that the area on the front lens covered by an oblique pencil is *greater* than that covered by the direct pencil. On the other hand, the obliquity of the pencil occasions loss of light, as shown by the dotted lines across it. The gain from one cause does not entirely compensate for the loss from the other, and there is not *perfect* equality of illumination; but in the common view-lens

there is loss from obliquity of incidence without *any* set off to counterbalance it. The orthoscopic lens has therefore the advantage as regards equality of illumination.

4th,—Perfection of focus, and freedom from spherical aberration. In the common view-lens *no* attempt is made to cure spherical aberration, or improve the focus, except by means of the stop. Everything is sacrificed to flatness of field. There would be *much* less spherical aberration in the central pencil if the lens could be turned with its convex side to the view. But in the orthoscopic combination spherical aberration may be better remedied, and the quality of the focus, both of the direct and oblique pencils, greatly improved.

5th,—Coincidence of the visual and actinic foci. With four glasses instead of two, more lines of the spectrum may be united, and therefore the chemical focus improved, so that the orthoscopic lens has the advantage in that respect.

6th,—In lightness and size the orthoscopic lens has the advantage over the meniscus.

Globe Lens.

This is a combination of two equal achromatic deep meniscus lenses, placed with their concave sides inwards and opposite, upon the same axis, and so that their outer convex surfaces form portions of the same sphere. Exactly midway between the lenses, and therefore at the centre of the above sphere, is placed a diaphragm having a small circular aperture.

It is evident that distortion will scarcely exist in the image formed by the above combination, inasmuch as every pencil will have its axis at emergence parallel to that at incidence. The field will also be tolerably flat, on account of the oblique incidence of the lateral pencils on the hollow surfaces of the two menisci. There is considerable aberration, but this is corrected by means of the small stop. This form of lens is much used in America, and is the invention of an American optician, the late Mr. Harrison, of New York. It has found but small favour in Europe, because the doublet lens of Mr. Ross is a cheaper and a better instrument. The globe lens may be considered a symmetrical doublet, in which the corrections are less perfectly accomplished than they are in Mr. Ross's unsymmetrical form. The instrument has also the disadvantage of being large and heavy in proportion to its focal length. It includes satisfactorily a wider angle than either the triplet or the deep meniscus lens. *See* "Globe Lens."

Ross's Actinic Doublet.

This is an unsymmetrical combination of two unequal achromatic deep meniscus lenses, placed as shown in the figure at p. 98, and having a stop so placed between them as to give no distortion of the image. It is the invention of Mr. Thomas Ross, of Featherstone Buildings, Holborn, and was introduced by him about two years ago. It includes the widest angle of view of any lens yet constructed for flat plates, and is the best view and copying lens that has yet been introduced by opticians. The definition is satisfactory at the margin of a picture including eighty degrees of angle, the illumination falls off but little at the edges, and there is neither distortion nor flare. Some excellent contrivances have also been introduced in the mounting. *See* special article "Doublet Lens."

Triplet.

This is an unsymmetrical combination, consisting of three achromatic lenses, placed at various distances apart upon a common axis. The front and back lenses are plano-convex, with their flat sides inwards; and the inner lens is plano-concave, with its flat side towards the front lens. The front convex lens is smaller, and has a shorter focus than the back lens, whilst the inner concave lens is smaller than either, and has the stop placed in contact with it. The principle of this combination consists in the oblique pencils having their focus lengthened by the inner concave lens; whilst distortion is prevented by the peculiar arrangement for producing parallelism in the axes of the emergent and incident pencils.

The triplet must now, to some extent, be regarded as a clumsy and complicated contrivance for effecting what can be easily effected by a doublet in a much simpler way and with fewer reflections, and consequent loss of light, although the large aperture with which it can be used will always command it a place among photographic optical instruments. It was one of the stepping-stones by which the discovery of, in some respects, a better instrument has been reached. An attempt has been made lately to introduce a triple form of portrait lens; but all such attempts, involving greater complexity, instead of greater simplicity, are to be condemned.

The triplet, in its symmetrical form, and with the concave lens uncorrected, was the invention of Mr. Sutton in 1858. It was subsequently modified in the manner described, by Ross, Dallmeyer and others. It is remarkable for having been the first view-lens used by photographers which gave no distortion of the image.

Periscopic Lens.

This is a symmetrical doublet, composed of a pair of equal, single, uncorrected, deep meniscus lenses of crown glass. It is a cheap substitute for the Ross actinic doublet, and one which cannot be recommended even on the ground of economy, for it is false economy to use a bad lens.

Panoramic Lens.

This is a view-lens for taking very comprehensive pictures, including ninety degrees or more of subject, upon a cylindrical or spherical glass. It is fully described in a special article, which see.

Light. What is light? Why does it render objects visible, exhibit different colours, produce chemical changes in bodies, and so forth? These are questions of the highest importance in science, and of especial interest to the photographer. We shall endeavour briefly to explain in the present article what light is, and why it produces many curious phenomena of which no photographer should be ignorant.

Two theories have been advanced with respect to the physical nature of light, one called the "Corpuscular," the other the "Undulatory" theory. On the former hypothesis it was supposed that a luminous body emits particles of light, just as a fowling-piece discharges a volley of small-shot, and that these minute particles, after travelling through space with immense velocity, at length impinge upon bodies. On the undulatory theory it is supposed that a luminous body communicates undulations to an elastic ether which pervades space, that these undulations are transmitted with prodigious velocity, and that they constitute light.

We speak of the corpuscular theory in the *past* tense, because it has now been abandoned by men of science as incapable of explaining some of the most important phenomena of light; and we speak of the undulatory theory in the *present* tense, because it is now generally adopted, and considered to rest on quite as satisfactory evidence as the law of universal gravitation. In the preface to Professor Airy's "Tract on the Undulatory Theory of Light," he expresses himself thus strongly on the subject:—

"The undulatory theory of Optics is presented to the reader as having the same claims to his attention as the theory of gravitation—namely, that it is certainly true, and that by mathematical operations of general elegance it leads to results of great interest. With regard to the evidence for this theory; if the simplicity of a hypothesis which explains with accuracy a vast variety of phenomena

of the most complicated kind can be considered a proof of its correctness, I believe there is no physical theory so firmly established as the theory in question. This can be felt completely, perhaps, only by the person who has both observed the phenomena and made the calculations; as to my own pretensions to the former qualification, I shall merely state that I have repeated nearly every experiment alluded to in the following tract. This character of certainty I conceive to belong only to what may be called the *geometrical* part of the theory; the hypothesis, namely, that light consists of undulations depending on transversal vibrations, and that these travel with certain velocities in different media, according to the laws here explained. The *mechanical* part of the theory, as the suppositions relative to the constitution of the ether, the computation of the intensity of reflected and refracted rays, &c., though generally probable, I conceive to be far from certain."

Such are the opinions of the Astronomer Royal, expressed in the year 1831, with respect to the certainty of the undulatory theory of light; but since that time some points of difficulty in the hypothesis have been cleared up, and it now rests on a firmer basis than ever. In fact, the corpuscular theory is now exploded, and we allude to it as a matter of history, as we might to any exploded system of Astronomy. Should the reader, therefore, find in any popular treatise on Optics the corpuscular theory treated with any sort of gravity or respect, or in any way than as a delusion, he may conclude that the author is but imperfectly acquainted with his subject.

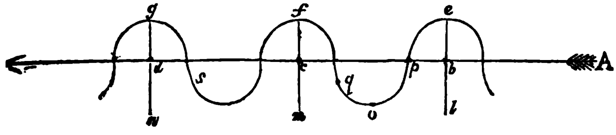
Light, then, is the undulation of an ether which pervades space, just as sound is the undulation of the air; but both the media and the species of undulation are different in the two cases. Air is a material ponderable substance—lumeniferous ether, an imponderable substance, and therefore not strictly material according to the definition of matter (*see* "Imponderable Agents"); still it *may* be, and no doubt *is* material, although it has not actually been *proved* to possess weight. Should space be filled with a material ether, however subtle, it would act as a resisting medium to the motions of the heavenly bodies, and in the case of the comets, which have but little mass, and move with enormous velocity, its effect as a direct force continually opposing their motion would be to cause them to describe smaller orbits in an appreciably shorter period of time. Now it is found that the periods of the comets of Encke and Biela *are* actually diminished by a few hours in every revolution round the sun; but this may happen in consequence of their passing through nebulous matter, which appears to surround the sun for a considerable distance, so that it does not afford absolute proof of

the materiality of the lumeniferous ether, although it increases the probability of its being subject to the common laws of grosser matter.

The species of undulations are also different in the cases of light and sound. In common light the vibrations of the molecules of ether take place in a line *at right angles to the direction* of propagation of the ray; in sound the particles of air vibrate *in the direction* of propagation. The undulations of light may be compared to those produced by throwing a stone into a smooth and deep pond of water; those of sound to the waves produced in a field of corn when the wind sweeps over it. In the former case, that of the water set in motion by the stone, each particle of water moves up and down in a *vertical* line; in the case of the field of corn, each ear of corn moves backwards and forwards in a *horizontal* direction, or something approaching to it. The illustration is certainly far from being perfect, but it may assist the reader in forming a true conception of the difference between light and sound. There is also a great difference between the velocity of propagation and length of the wave in the cases of light and sound. Light travels *in vacuo* at the enormous rate of 192,000 *miles* in a second, and the average length of a wave of light is about the one fifty-thousandth part of an *inch;* while sound only travels at the rate of about 1100 *feet* in a second, and the length of a wave of sound capable of affecting the auditory nerves of man lies between a few *inches* and several *feet*—the short wave, most frequently repeated, giving the high note, the long wave, less frequently repeated, the low note.

But, before carrying these analogies any further, we will endeavour to explain more clearly the precise nature of an undulation of light.

A luminous body is supposed to be a material substance the particles of which are in a state of intense agitation. These set in motion the molecules of ether next to them, and this motion is communicated from molecule to molecule, along a line of molecules, with amazing velocity, and in the following manner:—



ppose AB to be the direction of a ray of light, and *bcd* atoms

of ether; then the atom *b* oscillates or vibrates up and down along the line *el*, at right angles to AB; the atom *c* along the line *fm*; *d* along the line *gn*, and so on.

The velocity of the atom at *b* gradually decreases as it moves towards *e*, and on arriving at *e* altogether vanishes; the molecule then returns towards *b*, acquiring fresh velocity as it approaches *b*, attaining its maximum of velocity at *b*, then gradually losing it again as it approaches *l*, and losing it entirely at *l*; after which it returns to *e* as before, and so on. Similarly with respect to every atom along the line AB; and it must be clearly understood that no atom actually travels from A towards B, but merely continues to vibrate through an exceedingly small space in a line at right angles to AB.

This being understood, we have to explain how an *undulation* is produced and propagated. It will be remembered that, although light travels with amazing velocity, yet that velocity is measurable and finite, so that a molecule of ether, *b*, at one part of the line AB may be vibrating, while another molecule, *d*, is at rest. Suppose then we consider the state of the vibrating atoms which constitute a ray of light, at a particular epoch of time. It is evident that one atom may be at *e*, while another is at *p*, another at *o*, another at *q*, another at *f*, and so on. If then we draw a curved line through the instantaneous positions of the atoms, *epoqf*, that curve will represent an undulation, or wave of light; and the particles *e* and *f*, *q* and *s*, are said to be in the same "phase" of undulation; the length of the wave being the distance *ef*, or *qs*.

A ray of common light is composed of undulations which are propagated in the manner described in all possible planes passing through AB. A ray of "plane polarized light" is one in which the undulations are propagated in only *one* plane which passes through AB. A ray of "circularly polarized light" is one in which the curved outline of the undulation, instead of lying on a plane, forms a spiral round AB like the thread of a corkscrew, and called a "helix." A ray of "elliptically polarized light" is one in which the spiral, instead of being coiled, so to speak, round a *circular* cylinder, as in the former case, is coiled round an *elliptical* cylinder. The subject of polarized light will be discussed presently.

The effect produced by a ray of light is due to the blow of the last vibrating atom against the material substance upon which it is incident. As the undulations are propagated by the luminous body continuously, these blows follow one another in rapid succession, and a vast number of very small blows thus administered produce an appreciable effect in a finite time. This effect is, moreover, con-

siderably increased when a number of rays are brought to a focus, and act upon the same point.

LIGHT, therefore, is MOTION; or shall we say that light is the means by which a blow is transmitted from the luminous body to the body upon which light is incident?

Light travels *in vacuo* with uniform velocity; but there are different kinds of light, that is, light which exhibits different colours, viz., red, orange, yellow, green, blue, indigo, violet. These different colours are produced by *the different lengths* of the waves of light, as exhibited in the following table:—

Extreme red		·00075	millimètres.
line A in Spectrum . . .		·00074	"
B	" . .	·0006879	"
C	" . . .	·0006559	"
D	" . .	·0005888	"
E	" . . .	·0005265	"
F	" . .	·0004856	"
G	" . . .	·0004296	"
H	" . .	·0003963	"
I	" . . .	·00037	"
Extreme violet		·00036	"

Hence it appears that the waves of red light being the longest, the number of undulations in a given time are the fewest; and the waves of violet light being the shortest, its undulations are the quickest.

When light passes from vacuum into a transparent medium, or from a rare medium into a denser, the velocity of the waves is diminished, and *vice versâ*. The index of refraction, "μ," in geometrical optics, expresses in physical optics the ratio which the velocity of a wave of light *in vacuo* bears to its velocity in the medium into which it passes. This quantity "μ" is greater for violet than red light; it would appear, therefore, that their velocities being equal at incidence, the red ray travels faster through a refracting medium than the violet ray. There would consequently appear to be a connection existing between the length of a wave and the velocity of its propagation. This circumstance is stated as a difficulty at page 285 of Professor Airy's tract on the Undulatory Theory of Light. The difficulty has, however, been since removed by Professor Powell, of Oxford, who has demonstrated that within a refracting medium there *is* actually a difference between the velocities of red and violet light, the condition being that the intervals between the vibrating molecules of ether should bear a sensible ratio to the

length of an undulation, which condition is fulfilled within the refracting medium, although apparently not in space, where the velocity of light of all colours is the same.

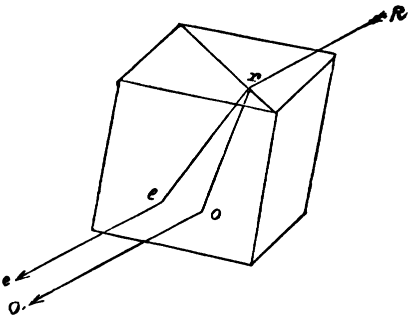
All material bodies are supposed to be more or less elastic, their particles not being in actual contact, and the interstices between them filled with lumeniferous ether. It is easy to conceive therefore that the chemical phenomena of light, and we may add of heat, and probably electricity, are produced by motion among the particles of the ether within the interstices of bodies, which communicates motion to the material atoms of the body itself, and alters their mutual arrangement. On this supposition, there can be no such thing as latent heat, latent light, or latent electricity, any more than there can be latent motion, which is a contradiction in terms. If we suppose light, heat, actinism, and the various forms of electricity, *when developed* in any body to be nothing more than the *motion* of an ether pervading all space, and filling the interstices of every substance, but varying in the length, velocity, and species of its undulations, we may explain by one general hypothesis a vast variety of astonishing phenomena due to agents between which many strong analogies are found to exist. Heat, for instance, is *proved* to be the undulation of an elastic medium, and its rays can be reflected, refracted, polarized, and made to exhibit interference just in the same way as rays of light. In short, there is a high degree of probability that the actinic, calorific, and luminous properties of the sunbeam are due simply to the different *lengths* of the undulations which are transmitted—a *long* wave (comparatively speaking) like the red exhibiting in a marked degree the effects due to *heat*, a *short* wave like the violet, those due to *actinism*, and a wave of *medium* length, those due to *light*.

The laws of the reflexion and refraction of light can be easily explained on the undulatory theory, but not without having recourse to a mathematical demonstration which is not sufficiently elementary for the present work. The reader is referred for this demonstration to Professor Airy's Tract, pages 277 to 296, and also to Herschel's "Treatise on Light."

We shall now consider some of the phenomena of POLARIZED LIGHT.

We have said that a ray of common light is composed of undulations which take place in all possible planes passing through the direction of the ray. Now the internal structure of certain substances is such, that when a ray of common light is incident upon them, only the undulations which take place in a *certain plane* or *planes* can be propagated through the substance, and the others are

arrested. An instance of this occurs in the case of Iceland spar, the crystals of which are rhombs, and are said to be "doubly refracting."



R*r* is a ray of common light incident at *r* upon a crystal of Iceland spar. On entering the crystal, the ray is divided into two, and suffers what is called "double refraction." One part of it, *ro*, is refracted nearly according to the usual law, and emerges in a direction *oo'*, parallel to R*r*. This is called the "ordinary" ray. The other part of it, *re*, suffers refraction according to a new law (which is somewhat complicated, and need not be enunciated in this place), and takes the direction *re*, after which it emerges in the direction *ee'*, parallel to R*r*, the direction of the incident ray. This is called the "extraordinary" ray. It is evident that after emergence the ordinary and extraordinary rays are parallel to one another. On examining their properties by methods which will be described presently, it is found that both the rays *oo'* and *ee'* are what is called "polarized," that is to say, the undulations take place in *one plane only*, the plane of the undulations of the ray *oo'* being perpendicular to that of the ray *ee'*. These planes are called the "planes of polarization," and the rays are called "polarized rays," the term being derived from the idea entertained by Newton, that a ray of light has sides or poles.

In the case of the Iceland spar, *both* the polarized rays are transmitted; but in that of a thin plate of tourmaline, cut parallel to the axis of the crystal, only one of the polarized rays is transmitted; and if this polarized ray be received upon another plate of tourmaline placed parallel to the first as regards its plane, but crossways

o the other in that plane, the ray will be altogether stopped. This effect may be popularly explained in the following way:—

A ray of common light, consisting of undulations in all possible planes, is incident upon a plate of tourmaline, which is to all appearance a transparent substance, but its internal structure is such as to resemble the parallel bars of a grating, or wires of a cage. If then we consider the undulations of the ray of common light as taking place upon a number of cards, all passing lengthways through the direction of the ray, it will be only one of these cards that can be pushed between the bars of tourmaline and the other cards will be stopped. Again, if we receive this one card, which is the polarized ray from the first tourmaline, upon a second plate of tourmaline, with its bars placed crosswise to the first, it will be completely stopped; but if the bars of the second tourmaline be placed parallel to those of the first, it will pass through readily enough. This explanation will perhaps convey a sort of popular idea of what is meant by polarized light. A ray of common light may be considered as round, like a ruler; a ray of polarized light as flat, like a riband.

Light is polarized by reflexion as well as by refraction, and all reflecting surfaces have the property of polarizing light more or less, according to the angle at which it is incident upon them. Sir David Brewster discovered that when the tangent of the angle of incidence is equal to the refractive index of the medium upon the surface of which light is incident, the reflected ray is *completely* polarized, and therefore its undulations take place in one plane only. For instance, the surface of plate glass is a reflecting surface, and the refractive index of plate glass is about 1·54, which is the tangent of an angle of 57°. If, then, a ray of common light is incident upon the surface of plate glass at an angle of 57°, it will be completely polarized by reflexion, and the reflected ray will not pass through tourmaline placed in a particular position; nor will it be reflected by another plate of glass placed in a particular position with respect to the first.

Polarized light consists of the same colours as common light, and the waves interfere in the same way. Photographic pictures may be taken by it. Photographic experiments with polarized light have not yet, however, received much attention. In the process of copying negatives by light transmitted through them after having suffered reflexion at the surface of a plane reflector, the whole of the light which falls upon the sensitive plate would be polarized if the reflector were placed at a particular angle with the incident rays.

By means of the law of the tangent, discovered by Sir David Brewster, the refractive index of opaque bodies may be ascertained by finding the angle of incidence at which complete polarization by reflexion takes place.

Although the subject of polarized light is one of great interest, yet the scope and object of this work do not permit us to say more about it. The phenomena next to be described are those of INTERFERENCE.

Returning to the figure at page 198.

If we suppose another undulation to be propagated along the line AB, in such a way as to combine with the first, the elevations and depressions of the first would be increased and the effect at the extremity B would be doubled; but if the second undulation were such that its highest point came exactly over the greatest depression of the first, the undulations would exactly counteract each other, and no effect would be produced at B. Between these two extremes there would be of course an infinite number of mean effects, according to the way in which the waves were superposed. In the same way, by letting a stone fall into a pond of still water, undulations are produced; and if a second stone be dropped in the same place, the undulations occasioned by the first may be either increased or diminished, or even altogether destroyed, and smooth water produced, according to the state of the first undulations at the instant of time when the second series were propagated. It would appear, therefore, that two rays of light falling upon the same spot might either produce increased or diminished brightness, or even absolute darkness; and this is found experimentally to be the case. For, let two rays of homogeneous light, red light suppose, emitted from different sources of light A, B, be transmitted through two pin holes in a darkened box, and received upon the same spot C, of a white screen. If the length of the beam AC be equal to that of the beam BC, or if the difference between AC and BC be any multiple of the length of a ray of red light, *i. e.*, any multiple of ·0000258ths of an inch, the undulations will exactly combine at C, and the intensity of the red spot produced by either ray singly will be doubled. But if the difference between AC and BC be any *odd* multiple of *half* the length of a wave of red light, so that the crest of the undulation of one ray may be superposed on the depression of the undulation of the other ray, darkness will be produced at C. Two rays of light incident upon the same spot may therefore produce darkness, and in the same way two rays of heat may produce cold, and two rays of sound silence. This remarkable effect cannot possibly be explained [illegible] corpuscular theory, for on the theory of the emission of

particles, more particles ought to produce more light instead of darkness.

The phenomena produced by the interference of waves of light are among the most beautiful in optics. Nothing can exceed the splendour of the coloured images exhibited in many of the experiments which are illustrative of interference; but in this place we can only briefly allude to the fact that the colours produced by thin films are caused by the interference of the rays reflected from the inner susface of the film, with those reflected from the outer surface, while the iridescence of mother of pearl, and the varied hues of iridescent ornaments, are occasioned by fine lines existing in the surfaces of these bodies, which cause the interference of waves of light. Newton's rings, for instance, and the varied colours of soap-bubbles, are produced by interference.

We now pass on to the DIFFRACTION OR INFLEXION of Light.

It is assumed in geometrical optics that light can only proceed in a straight line, and therefore that a body which intercepts it must necessarily cast a shadow of definite form, sharp outline, and uniform intensity of blackness. This assumption may have its uses in geometrical optics, but in physical optics it is found to be not strictly correct, for it appears that a ray of light, or line of undulations, is actually bent round the corner, so to speak, in passing close to the edge of an opaque body; so that when an opaque body which intercepts the light proceeding through a small orifice into a darkened chamber is sufficiently narrow, and at a proper distance from the opening, the rays which are bent round the opposite sides of it, interfere and produce alternate bands of light and darkness across its shadow; and in every case, whatever may be the shape or size of the intercepting body, it is found that interfering waves of light produce a series of dark lines and coloured spaces round the edge of its shadow. To explain this phenomenon it is supposed that when light is admitted through a small hole into a darkened chamber, the central rays of the pencil pass straight on and produce a light spot upon the opposite wall, while the undulations which immediately touch the sides of the opening have the property, like those of sound, of communicating undulations obliquely to the ether within the box, and thereby of producing refracted rays which travel with diminished velocities, and, by interfering at the edge of the shadow, prodnce the dark lines and coloured spaces in question.

It has been thought by some persons that the inflexion of light round the edges of dark objects which intercept it might tend to produce indistinct positives, when these are taken in a copying camera by light which is transmitted through a transparent negative.

But this idea is erroneous. We have shown in the article on the "Condenser" that the light parts of a transparent negative which has either the sky, or a luminous background, or a light and condenser, behind it may be considered as made up of a system of bright points, each of which is the origin of a divergent pencil of light, so that the bright point immediately adjacent to the edge of any dark part of the negative is the origin of a divergent pencil of light which is refracted by the lens to a focus. Now it is evident that any rays of light which may be bent by inflexion round the edge of the dark part of the negative would only add so many more rays to this divergent pencil, and that the lens would refract them to the same focus as the other rays of that pencil. They could not, therefore, produce indistinctness in the picture. It is important that this should be clearly understood. The indistinctness produced by copying-lenses is occasioned by spherical aberration not being properly corrected in them.

We must now draw to a close our remarks on the interesting subject of the physical nature of light with a few observations on the colour of natural objects, and the theory of the decomposition of light by absorption.

The colour of a natural object (when its surface is not iridescent and the colours produced by interference), is due to its absorbing all the rays of light which fall upon it, and reflecting or radiating only those of its particular colour. The colour of a substance is therefore due to some peculiarity of its structure. A black substance absorbs all the rays of light and reflects none, becoming at the same time heated, or, to speak more correctly, radiating heat rays, which seem to indicate that the absorbed light becomes heat. A white substance, on the contrary, reflects *all* the rays of light, and absorbs none, and does not become heated (comparatively speaking). This again bears out the idea of the conversion of absorbed light into heat.

The reader may inquire what, in general, becomes of absorbed light, or lost light. We cannot do better than quote the following reply of Sir John Herschel to this question:—

"The question, 'What becomes of light?' merges in the more general one, 'What becomes of motion?' and the answer on dynamical principles is, that it continues for ever. No motion is, strictly speaking, annihilated; but it may be divided, and the divided parts made to oppose, and in effect destroy one another. A body struck, however perfectly elastic, vibrates for a time, and then appears to sink into its original repose. But this apparent rest is nothing else than a state of subdivided and mutually destroying motion, in which every molecule continues to be agitated by an indefinite multitude

of internally reflected waves, propagated through it in every possible direction from every point in its surface on which they successively impinge. The superposition of such waves will, it is easily seen, at length operate their mutual destruction, which will be the more complete the more irregular the figure of the body, and the greater the number of internal reflections."

The theory of the decomposition of light by absorption, brought forward some years ago by Sir David Brewster and since advocated by numerous popular writers, has not been adopted by men of science, but, on the contrary, condemned by Professors Airy, Helmholtz, and others. The idea that the seven colours of the spectrum can be decomposed by absorption into three, viz., red, blue, and yellow, has been shown to be an illogical inference from experiments imperfectly conducted. There must be considered to exist as many different kinds of light as there are different lengths of waves within the limits of the visible spectrum; and when the undulating ether ceases to produce the phenomena of light and colour, its undulations may be called heat, actinism, or as the case may be, according to the effects they produce on grosser matter.

With respect to the chemical action of light, this must be considered as due, in all probability, to the vibratory motions of the ether within the interstices of a body establishing a mechanical disturbance amongst its particles, which either enables or compels them in certain cases to form a new arrangement, or enter into new combinations with each other. By adopting the notion that there is no absolute contact between atoms, and that all bodies are more or less elastic, we can readily imagine that the undulations of the universal ether may act as a mechanical force in promoting chemical combination, or decomposition, determining cystallization, and so on. We need not in this place enumerate any of the principal phenomena of actinism, but it may be well to define clearly what the term actinism means. Assuming, then, as highly probable, that the phenomena of heat, light, actinism, and the various kinds of electricity are produced by undulations of the same universal ether, which differ only in the lengths of the waves and the velocities of their propagation, we should define actinism to include all such chemical changes as are effected by waves of ether varying in length between that of a ray of yellow light and of an invisible ray of the greatest ascertained refrangibility. According to this definition, whatever the chemical effects of the red and yellow rays may be, they would be attributable either to heat or light, and not to actinism, for both heat and light are known to produce important chemical changes. But, after all, a definition of this kind is only of use until, by some fortunate

generalization of causes, we are enabled to substitute a better one for it.

The question of "Latent Light" is discussed with that of "Latent Heat;" (*q.v.*)

Lignin. $C_{36}\,H_{22}\,O_{22}$. This substance may be considered as a compound of carbon and water. It is of great importance in photography, first, because pyroxyline is made from it; and secondly, because paper is a nearly pure form of it.

Lignin forms the solid framework of plants. It is obtained in a pure form by removing from sawdust, or any other kind of finely divided woody fibre, all soluble matter, by steeping it in hot and cold water, boiling it in alcohol, water, solution of potash, weak hydrochloric acid, and lastly in distilled water, and then drying the residue at 212°. Or in addition to the above treatment, it may be bleached by chlorine, and rinsed in acetic acid. The cleansed and bleached fibres of linen or cotton are tolerably pure lignin.

Pure lignin is white, tasteless, and insoluble in water, alcohol, ether, and the oils, or hydro-carbons. Its sp. gr. is 1·5. When acted on by a cold concentrated solution of sulphuric acid, it is converted into dextrine and grape sugar; cold concentrated nitric acid converts it into xyloidin, having nearly the same properties as that obtained from starch; the continued action of hot nitric acid on it produces oxalic acid; hydrochloric acid blackens, but does not dissolve it, and the acid becomes red or brown; a hot and strong aqueous solution of potash produces oxalate and acetate of potash. It is evident, therefore, that in the process of making pyroxyline by acting on lignin with nitro-sulphuric acid, other compounds may be formed which would in general be injurious in collodion.

Lignin combines energetically with various salts and metallic oxides, and this property is very important in the arts of dyeing and calico printing, in which colouring matters are made to combine with textile fabrics; and also in the preservation of timber from dry rot, and of canvass from mildew, &c. This property lies also at the foundation of the photographic processes on collodion and paper; for had lignin, in its natural form of paper, or in its altered form as pyroxyline, no power of combining chemically with metallic oxides, the photograph would merely lie upon the surface of the film, and could be blown by a breath or removed by a touch from it. It may, however, be the presence of the organic matter that is necessarily associated with the material of photographs which either causes or assists them to fade.

Wood may be preserved from dry rot by Kyan's patented process

of steeping it in a solution of bichloride of mercury; or in one of sulphate of iron, sulphate of copper, or chloride of zinc. The latter salt is especially useful in protecting sail cloth from mildew. Alumina combines energetically with calico and linen, and is much used as a mordant in dyeing.

Woody fibre appears to be permanent in dry air, or completely under water, but not when exposed alternately to the action of air and damp; the ultimate effect of the gradual process of decay being the removal of all the elements but a portion of the carbon from the lignin. Hence it is that some forms of coal, as anthracite, are nearly pure carbon. One of the products of the decomposition of lignin is "fire damp;" another, carbonic acid. The beds of coal in different parts of the world are supposed to have been formed by the decomposition of the forests of monster ferns which at one time covered a large portion of the earth's surface, in all latitudes, before it cooled down to its present temperature, and when its atmosphere was too much impregnated with carbonic acid to be fit for the support of animal life.

Lime, Carbonate of. $CaO, CO_2 = 50$. This substance forms one of the most abundant compounds of rocks in almost every part of the world, in the shape of marble, limestone, chalk, &c. In Photography, precipitated chalk is often used for neutralizing acid solutions of silver, gold, &c. It is particularly useful in depriving chloride of gold solutions of their excess of hydrochloric and nitric acids, and thus suiting them for toning photographic prints; for this purpose, pounded, or better still, precipitated chalk, is shaken up in a bottle with the acid gold solution; the weak carbonic acid is expelled by the stronger acids and escapes; chloride of calcium and nitrate of lime are formed, and the solution after a time becomes neutral.

Lime, Chloride of. The exact chemical composition of this substance is a subject of dispute among chemists. It emits the peculiar odour of hypochlorous acid when exposed to the air, and at the same time absorbs carbonic acid. This constitutes its value as a disinfecting agent. Its bleaching properties are well known. In photography it is sometimes used in the gold toning bath to neutralize the acidity of the solution, but it must be used with great discretion, otherwise the chlorine which escapes attacks the silver image, converting it into the white chloride of silver. In the case of over printed pictures, a weak aqueous solution of it might occasionally be found useful in reducing excessive vigour. On the other hand, there is considerable disadvantage attending its use,

both in the toning bath and in plain aqueous solution, viz., that it attacks the half tones more strongly than it does the deep shadows.

On account of its powerful oxidizing properties, this substance has also recently been recommended for eliminating the last traces of hyposulphites from washed photographic prints. This it effects by converting the hyposulphites into innocuous sulphates. It is doubtful, however, whether the advantage gained will counterbalance the disadvantage of an enfeebled print.

By means of chloride of lime, silver stains on the hands, &c., may easily be removed, and this is a more convenient method than the one generally adopted with cyanide of potassium. Make up a little of the dry chloride into a paste with water, acidulated with any acid, and apply it to the stains, by hard rubbing. If the stains have been recently formed, they will quickly disappear, but if they are old, a little friction with pumice stone may be required.

Lime-light. When a jet of mixed oxygen and hydrogen gases is ignited, the flame is scarcely visible although intensely hot; but by introducing solid matter into it, by causing it to play upon a ball of lime, a most intense white light is produced. (*See* "Flame.") This is called the "Drummond Light." It is highly actinic, but less so than the light produced by the charcoal points of a voltaic battery. The Drummond Light is employed at public institutions for the exhibition of dissolving views and microscopic specimens. Another form of lime light, invented by Messrs. Horne and Thornthwaite, of Newgate Street, consists in urging a jet of oxygen through the flame of a spirit lamp, and causing it to play upon a ball of lime. The light is very white and intense, although not equal to that of the Drummond Light. It is called the "Oxycalcium Light" (*q.v.*), and is very convenient for exhibiting the magic lantern to a small assemblage of spectators, as well as in certain photogaphic operations when conducted by artificial light.

The incandescent lime is gradually dissipated, or sublimed, and the lime ball must be renewed from time to time.

Lime-toning Bath. *See* "Calciochloride of Gold."

Line. The one-twelfth part of an inch.

Linseed Oil. A drying oil, obtained by expressing the seeds of common flax, which yield from 20 to 25 per cent. of their weight. Its sp. gr. is ·9395 at 52°. It may be cooled down to 40° without solidifying. It is soluble in 40 parts of cold, and 5 parts of boiling alcohol and in 1·6 parts of ether. A small quantity of the alcoholic

solution is sometimes added to spirit varnishes to diminish their brittleness.

The drying quality of linseed oil is increased by boiling it from three to six hours, and then stirring into it from 7 to 8 hundredths of its weight of litharge; (*q. v.*) In this operation the lead is partially reduced, and a little oleate and stearate of lead are formed, which the oil holds in solution.

A mixture of boiled linseed oil and mastic varnish forms a gelatinous substance much used by artists, and called "Magilp."

Linseed oil is extensively used in paints and varnishes, and also in printer's ink.

Liquor Ammoniæ. Aqueous solution of Ammonia; *q. v.*

Liquor Potassæ. Aqueous solution of Potash; *q. v.*

Liquorice Sugar. *See* "Glycyrrhizine."

Litharge; Massicot. Protoxide of lead, Pb. O=112. The "galena," or native sulphide of lead, from which lead is commonly obtained, sometimes contains silver. When this is the case a blast of hot air is passed over the fused mixed metals. This oxidizes the lead, but has no effect upon the silver. The oxide of lead, or litharge, is therefore blown off, and collected in a suitable chamber.

Litharge is a heavy yellow powder, slightly soluble in water, to which it gives an alkaline reaction. It melts at a red heat, and tends to crystallize on cooling, but on reaching 212° falls into a powder. When melted it combines energetically with siliceous matter, and would destroy an earthen crucible.

Litharge is much used by painters as a dryer. (*See* "Linseed Oil.") Dark red litharge is called "Litharge of Gold;" the pale variety, "Litharge of Silver."

Water which has been filtered through litharge increases the energy of the developer which is dissolved in it, but this should be used immediately, for it will not keep. There is also danger of its producing fog upon the plate.

Lithium, Iodide of. LI+6 aq.=188. The iodide of lithium has been recommended for photographic use because of its greater solubility in alcohol than many other iodides. It is, however, so very deliquescent that it can with difficulty be preserved in the dry state. It may be prepared by mixing, in concentrated aqueous solution, equivalent weights of sulphate of lithia and iodide of calcium, then evaporating *in vacuo* over sulphuric acid, and exhausting the dry product with strong alcohol.

Litmus; Tournesol; Lacmus. A violet-coloured paste, sold in the form of blocks or pyramids. It is made, like archil, by treating certain lichens which grow on rocks by the sea side, in the following manner:—

They are cleaned and ground into a pulp with water; then, ammoniacal liquors from the gas works are added, and the mass frequently stirred and exposed to the air as much as possible. In this way a peculiar colouring matter is produced, which when perfect is pressed out, and mixed with chalk or plaster of paris so as to form a paste. This is the "Archil" of commerce, much used as a purple dye. Another variety, made in the same way in Holland, from the lichens called *Roccella tartarea*, and *Lecanoro tartarea*, is called "Litmus." It has a violet-blue colour, is easy to pulverize, and is partially soluble in water and dilute alcohol, leaving a residuum composed of carbonate of lime, clay, silica, gypsum, and oxide of iron combined with the dye.

The colour of litmus is reddened by acids, and afterwards restored by alkalies. Litmus is much used for making Test-papers; *q. v.*

Liver of Sulphur. The compounds obtained by fusing potash or its carbonate with sulphur, have been designated *livers* of sulphur, on account of the colour which they assume. This substance is very useful to the photographer in reducing silver residues from old hyposulphite baths, &c. It may be prepared by heating in a covered crucible eight ounces of carbonate of potash with from four to six of sulphur, till the whole forms one uniform mass. To use it, when the mass is cold, break it into fragments and throw them into the waste solutions. After a time the whole of the silver will be precipitated as a sulphuret, which may be reduced to the metallic state by fusion. It is better to have always a large excess of liver of sulphur in the waste jar.

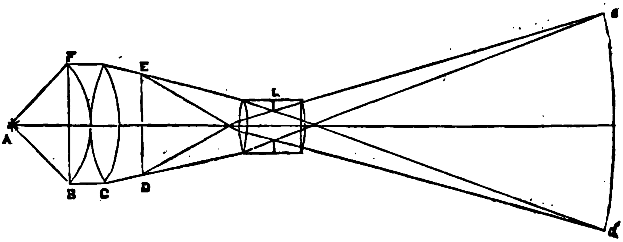
Logwood. The heartwood of the *Hæmatoxylon Campechianum*, of the West Indies; brought to Europe in logs about 3 feet in length. The infusion of this wood is of a dark red or purple colour, and is used in dyeing and staining. It gives purples and blues, and also blacks of various intensities by means of iron and alum bases. Its colouring matter is called "Hematin." When chipped logwood is for some time exposed to the air it loses a portion of its dyeing property.

Decoction of logwood absorbs oxygen from the atmosphere, and will then precipitate gelatine, a property which it did not at first possess.

Lunar Caustic. Nitrate of silver fused and moulded into sticks. Commercial lunar caustic is sometimes adulterated with the nitrates of potash, zinc, lead, and copper, and should not be used in Photography.

Lutes. Used for securing the junctions of vessels, and preventing the escape of their contents when submitted to various chemical operations, as distillation, &c. The lutes used for ordinary purposes are slips of bladder, linseed meal made into paste with gum water, albumen and quick lime, putty, and a fat lute composed of pipe clay and drying oil. Windsor loam is used as a lute to withstand a high temperature; this is made by mixing clay and sand into a stiff paste with water. If intended to vitrify, borax or red-lead should be mixed with it.

Magic Lantern. An instrument for exhibiting magnified images of transparent pictures upon a screen. The arrangement of the different parts of the apparatus will be understood from the following figure.



A is the source of light; which may be either an argand lamp with a reflector behind it, or better still, a lime-ball rendered incandescent by passing a jet of oxygen through the flame of a spirit lamp, and causing the flame to act upon it. (*See* "Oxycalcium Light.") BC are the lenses of the condenser (*see* "Condenser"), which collect all the rays of light which proceed from the lamp, within the angle F A B, and cause them to converge in such a way as to pass through the transparent picture ED. The front lens FB is plano-convex, the back lens C a "Crossed lens;" *q. v.* ED is the transparent picture, which must be placed in an inverted position. L is a combination of lenses having short focal length; and *de* the screen on which the magnified image of ED is received, and rendered visible.

The distance of the slide ED from the lens at L is rather greater than the principal focal length of that combination, and then the screen, which is in the other conjugate focus of the lens, is at a *much* greater distance from it. A pencil diverging from E is brought to a focus at *e*, and a pencil from D at *d*; and so on. The combination of lenses at L which the photographer will find the best is the common portrait combination; and when this is used, the posterior lens of the combination should be placed next to the picture, and a stop should be placed between the lenses, as occasion may require. The focus of the condenser should fall pretty nearly in the lens at L which is nearest to the screen.

In order to obtain a perfectly flat field upon the screen, the picture ED should be painted, or photographed, upon a curved surface like a watch glass.

Magic lantern slides are painted in transparent colours ground in Canada balsam.

Photographic slides for the magic lantern may either be printed upon dry collodionized or albumenized glass plates, by superposition of the negative, or they may be printed by the wet collodion process, by means of a Copying Camera. The glass should be perfectly transparent in the light parts; but stereoscopic slides backed with ground glass may be exhibited in the magic lantern, and produce a tolerably good effect.

Sometimes the screen, or sheet, on which the image is thrown is wetted in order to render it semi-transparent, and the spectators are then placed behind it, and consequently see nothing of the apparatus.

Dissolving views are produced by means of two lanterns, the axes of which are directed towards the same part of the screen, and each of which contains a slide. When a view is to be changed, the cap which closes one lantern is gradually opened, while the other lantern is being shut off. This is done by turning a handle which puts in motion a piece of mechanism contrived for the purpose.

Magic Photographs. These amusing toys may be made thus:—Print from a negative as usual, either on albumenized or plain paper, but do not tone in gold. Fix in hyposulphite of soda, and thoroughly wash. Then immerse the prints in a saturated solution of chloride of mercury till all trace of an image has disappeared. (If the solution be warmed the action is much more rapid and complete.) Afterwards wash and dry. When it is required to redevelop them, have a piece of blotting paper previously soaked in hyposul-

phite of soda and dried, moisten it with common water, and while still wet press it down on the invisible image. Instantly the picture will reappear with more than its original vigour. If it be again washed, the image will probably be very permanent. Sir John Herschel discovered this process many years ago.

Magilp. A gelatinous compound made by mixing boiled oil and mastic varnish, in about equal proportions. It is much used by artists for thinning oil colours, and "glazing" on delicate tints in finishing of the picture.

Magma. When a mixture of substances forms a thick pasty mass it is called a "Magma."

Magnesium. Mg. = 12. This is a silver-white metal of crystalline structure and somewhat brittle. It is obtained by acting on chloride of magnesium with metallic sodium, and is afterwards purified by distillation through a current of hydrogen. Afterwards it is formed into wire by forcing it while hot through small apertures in a steel block.

Its chief use in Photography is for the purpose of illumination, possessing, as it does, the power of emitting a most dazzling bluish white light when burnt in air or in oxygen. This light is strongly actinic, and hence it is sometimes used by photographers in dull weather, or at night, for taking negatives when they could not otherwise be obtained.

Several ingenious contrivances for lamps with reflectors have been proposed in order to facilitate the production of a regular and constant flame from the burning wire, but all of them are more or less liable to objection. The light emitted is more actinic than that produced by any other artificial means.

Magnesium, Iodide of. Mg. I + aq.? This salt is sometimes used for iodizing collodion, but it is generally considered inferior to some other iodides.

To prepare it, heat crystallized sulphate of magnesia in a porcelain vessel on a sand bath, until all the water of crystallization has been expelled and a white mass remains. Rub up 50 grains of this mass with about 65 grains of powdered iodide of potassium. Then agitate the whole in a bath with four ounces of strong alcohol for about a quarter of an hour. Filter out the insoluble sulphate of potash, &c., and add two drachms of the filtered solution to each ounce of plain collodion.

Magnesium, Oxide of; Magnesia. Mg. O = 20. A white,

heavy, insipid powder, nearly insoluble in water, and having a very feeble alkaline reaction on vegetable colours. It absorbs carbonic acid and water from the air, but these may be driven off again at a red heat. Its salts have in general a bitter taste, and many of them, in particular the chloride of magnesium, and nitrate of magnesia, are deliquescent. The affinities of magnesia for the acids are in general about equal to those of ammonia.

Malt Process. By this dry process good negatives can be obtained as follows:—Sensitize and thoroughly wash the colodionized plate, as usual in all dry processes. Then pour on and off the plate several times good sound Burton or Edinburgh ale, and set aside in a dark cupboard to dry, or dry by artificial heat. Another method for making the preservative is this: infuse in four ounces of hot, not boiling, water, one ounce of ground malt. Let it stand for an hour or two in a warm place, with occasional stirring, then filter. This solution will not keep longer than a few days after it has been prepared. Conduct the development as in the Fothergill process.

Manganese, Black Oxide of; $Mn. O_2$. This is a mineral which occurs native in Devonshire, Somersetshire, and Aberdeenshire. Its chief, and perhaps only use to the photagrapher, is as a source of oxygen gas for the oxycalcium light. When heated in a retort to a full red heat it gives off oxygen, and becomes converted into a sesquioxide, $Mn_2 O_3$; it should be well dried before being put into the retort. When added, in the proportion of about one part of black oxide of manganese to three parts of chlorate of potash, and moderately heated in a retort, over a common fire, oxygen is abundantly given off. The presence of the manganese greatly assists the evolution of oxygen from the latter salt, without appearing itself to undergo decomposition.

Marine Glue. Digest from 2 to 4 parts of india rubber, cut into small pieces, in 34 parts of benzole, and promote solution by heat and agitation. The solution should have the consistence of thick cream. Add to it 62 parts of powdered shellac, and melt the mixture over the fire, stirring it well. Then pour it upon plates of metal, so that it may cool in sheets.

To use it, melt it in an iron vessel at about 250°, and apply it with a brush to the surfaces to be joined. Let it get hard; then moisten the surfaces with benzole, and press them into contact.

Marking Ink. First apply the following mordant to the linen:—

Carbonate of soda	2 ozs.
Distilled water	1 pint.

Then write upon it, when dry, with the following ink :—

Nitrate of silver	1 drachm.
Powdered gum arabic	2 drachms.
Sap green	1 scruple.
Distilled water	1 ounce.

Or the following ink may be applied without a mordant :—

Nitrate of silver	1 ounce.
Carbonate of soda	1½ ounce.
Tartaric acid	2 drachms.
Ammonia	2 ounces.
Archil	½ oz.
White sugar	6 drachms.
Powdered gum arabic	10 drachms.
Distilled water	quantum suff.

Dissolve the nitrate of silver and carbonate of soda separately, then mix, wash the precipitate, put it into a mortar, and add the tartaric acid until effervescence ceases. Add the ammonia to dissolve the tartrate of silver, then mix in the other ingredients with the distilled water.

Mastic. A species of resin much used in varnishes. It comes from the Levant, and occurs in small drops or tears of a pale yellow colour, which are the produce of the *Pistacia lentiscus*. It contains about 90 per cent. of a resin easily soluble in alcohol (used for varnishes), and a viscid and difficultly soluble resin.

Matches, Congreve, or Lucifer. Make the following ingredients into a paste with water, and dip the matches into it :—

Gum arabic	16 parts.
Phosphorus, powdered	9 „
Nitrate of potass	14 „
Black oxide of manganese	18 „

Mealiness of Prints. This term has been applied to photographic prints characterized by numerous small spots of irregular toning, and general lack of vigour. They arise most often from a badly prepared toning bath, but sometimes, also, from the nature of the paper, some kinds being more liable to this defect than others.

Measles. When prints are imperfectly fixed, the appearance presented is very similar to that of the same disease in the human subject. Hence the name. They are best seen by looking through the print, because they exist chiefly in the texture of the paper. The specks consist of sulphide of silver, which, when once they

are formed, cannot be removed by hyposulphite of soda, nor by washing. They can, however, in most cases be easily avoided by fixing the prints in stronger solutions of the hyposulphite.

Measures. *See* Tables at the end.

Melainotype. This positive process is of American orgin, and derives its name from the black colour of the material which supports the picture. Very thin sheets of iron are coated on both sides, and on the edges, in fact, entirely covered with a kind of black japan varnish. The side which has to receive the collodion must be very smooth and highly polished. When collodionized, excited, and in every way treated as in the positive process on glass, these plates yield beautiful results, and possess the great advantage of being less fragile, so that they can be sent by post, &c., without danger of breakage.

Melting Point of Metals. The following table is extracted from Turner's "Elements of Chemistry":—

	Metal	Fahrenheit.
Fusible below a red heat, or 980°, the heat of a common fire being about 1200°.	Mercury	—39°
	Potassium	136°
	Sodium	190°
	Tin	442°
	Cadmium	450°
	Bismuth	497°
	Lead	612°
	Zinc	773°
	Antimony	—
	Silver	1873°
	Copper	1996°
	Gold	2016°
	Cast Iron	2786°

Mercury. Hg.=100. A white metal, fluid at ordinary temperatures, and solid at —40°. It boils and becomes vapour at 660°, and emits vapour at all temperatures above 40°. The principal ore of this metal is the sulphide, or native *cinnabar*.

Perfectly pure mercury may be agitated in contact with air, oxygen, hydrogen, nitrogen, carbonic acid, and alcohol; but when impure it becomes coated with a gray powder, which is a mixture of the oxide of the foreign metal and finely-divided mercury. On the other hand, when mercury is agitated with water, ether, or oil of turpentine, it is reduced to gray powder, which is composed of minute globules of mercury blended with the foreign body.

Mercury combines with several of the metals, and forms "amalgams."

Mercury, Chloride of. Hg Cl=135·5. This salt, generally known under the name of *corrosive sublimate,* is of considerable photographic importance. It can be economically prepared by subliming, at a red heat, equal portions of the sulphate of the protoxide of mercury and dry chloride of sodium. The chloride of mercury passes over and forms a transparent and dense crystalline mass, whilst sulphate of soda remains behind in the retort.

It is soluble in about sixteen parts of cold, and in about three of boiling water. It is more soluble in ether and alcohol. A little hydrochloric acid added to water increases its solvent powers. Being very poisonous, this salt should be used with great caution.

This salt is sometimes used as an intensifier for negatives; the *modus operandi* being as follows:—Pour over the negative a cold saturated solution of the chloride, until the image becomes of a whitish gray colour. Thoroughly wash the film, and treat it with a one-grain solution of iodide of potassium till the image assumes a greenish colour, which is very non-actinic. Negatives treated in this way print excellently for a while; but, after being exposed to light many times, the image becomes too intense for yielding good prints.

Mercury, Oxide of. There are two oxides of mercury, viz., the black, $Hg._2O$, and the red, Hg. O. Both are salifiable. The black oxide is reduced by light into Hg. and Hg. O. The red oxide becomes black when heated, but red again on cooling. It is superficially reduced by light, and becomes black. These oxides form a great number of curious and important salts.

Mercury Bath. The box in which daguerreotypes are developed by the fumes of mercury. It should be made of iron, in the form of an inverted pyramid, provided with a thermometer, and supported upon an iron stand. The plate should be placed horizontally over the mercury. This form of apparatus was first used in America, and may now be seen at most photographic depôts in this country. It is very simple and inexpensive.

Metagallic Acid. An organic substance formed by the oxidation of gallic acid. It combines with oxide of silver, and other metallic oxides, and displaces carbonic acid from the alkaline carbonates. It is produced by rapidly heating gallic acid up to 480°, when carbonic acid and water are evolved, and metagallic acid remains as a black shining substance, insoluble in water, alcohol, and ether. Its equivalent is supposed to be $C_{12}H_3O_3,HO$.

Metagelatine. When a strong solution of gelatine has been boiled and cooled several times, it ceases to gelatinise on cooling, and remains fluid. In this state it is called metagelatine, and may be used successfully as a preservative substance in the collodion process. It is a much less powerful reducing agent than honey, and therefore less likely to fog the collodion plate.

The mode of preparing metagelatine, originally described by Mr. Maxwell Lyte, is as follows:—

Dissolve $1\frac{1}{2}$ ounce of pure white gelatine in 10 ounces of boiling water. Add 60 minims of strong sulphuric acid diluted with $2\frac{1}{2}$ ounces of distilled water. Boil for five minutes, and then let the liquid cool. Then boil it again for five minutes and let it cool. Should it still gelatinise on cooling, repeat the operation. When it remains fluid on cooling, neutralise the acid with powdered chalk, and remove the insoluble sulphate of lime by squeezing the mixture through a cloth.

Metagelatine dries to a hard transparent film upon the collodion. When intended to be used as a moist preservative, a little golden treacle (not honey, nor glucose) should be added to it.

Methyl. Me. (Greek, μεθυ, wine, and ὑλη, wood.) A hypothetical substance, the composition of which is assumed to be $C_2 H_3$, and which forms the supposed base of a series of methyl compounds analogous to those of ethyl.

Methylated Alcohol. *See* "Alcohol."

Methylated Ether. *See* "Ether."

Methylic Alcohol. Me. $O + H O = C_2 H_3 O + H O$. This substance, called "wood alcohol," or "pyroxylic spirit," is a hydrated oxide of methyl, and analogous to the alcohol of the ethyl series. It is one of the products obtained from the distillation of wood. In its properties it greatly resembles alcohol, and as there is no duty on it, it is much used as a solvent for varnishes, &c. Its taste is hot and pungent; sp. gr. ·800; it boils at 150° at the mean pressure of the atmosphere; mixes in all proportions with water, alcohol, and ether; and is neutral to test paper.

By a method of purification and re-distillation through charcoal, Mr. Eschwege has been enabled to free this alcohol from its nauseous smell, and in a great measure from its hot, pungent taste. In consequence, the legislature have forbidden this method of purification; which is much to be regretted, because Mr. Eschwege's preparation is a capital solvent, without the aid of ether, for pyroxyline, and forms a collodion admirably suited for hot climates, where

great difficulty exists in coating a plate evenly with the ordinary collodion, on account of the rapid evaporation of the ether.

Methylic Ether. Me. O = C_2H_3O. When equal parts of "wood alcohol" (or "pyroligneous spirit," as it is termed) and sulphuric acid are distilled together, a gas is evolved, which, when collected over mercury and purified by potash, is found to consist of oxide of methyl, or methylic ether. It has an ethereal odour, with a taint resembling peppermint, and may be taken up abundantly by alcohol, or wood-alcohol, or ether.

Mica. A transparent mineral, of a pearly lustre, mostly brought from Siberia and India. It may be divided into sheets as thin as paper, which are hard and flexible. It is an ingredient of granite and gneiss. It is sometimes used in Photography instead of glass.

Micro-Photography. This term is now used to designate the *reduction* of negatives to a very minute size, and serves to distinguish it from the process denominated "Photo-micrography," (*q. v.*), which means the enlargement, by means of Photography, of microscopic objects.

Micro-photography has received considerable attention in this country; chiefly, however, by amateurs. In France it is carried out commercially on a large scale by several firms. M. Wulff, Rue Richelieu, Paris, has published a short treatise on the subject, wherein he describes a very perfect apparatus, whereby these *bijoux* photographs can be taken with the greatest ease by any one conversant with the manipulations of Photography. A translation of this article, with illustrations, was, by permission of the author, published in the "British Journal of Photography," of March 24th, 1865. For very detailed information we refer our readers to that article, or to the original work.

On a small scale an apparatus can be extemporised very readily by those who know how to use the microscope; but if the instrument is a valuable one, it is advisable not to run the risk of injuring it by nitrate of silver or other chemicals. In the year 1857, Mr. Hislop communicated to the North London Photographic Association a description of a very cheap and convenient apparatus, which we have used with much success. It consists of a rigid mahogany board of about three and a half feet long and six inches wide. At one end there are two uprights, between which a miniature camera, fitted with a one-inch microscopical objective, can be raised up or down, so as to place the centre of the lens opposite the centre of the negative, whatever may be its size. The object-glass is screwed

to a brass tube projecting from the camera towards the negative, the tube being fitted with stops of different sizes. A micrometer head, for fine adjustments of the lens, is also necessary, because microscopic objectives are only corrected for the visual rays. In focussing, the best glass is one coated with collodion, sensitised and washed. The sharpest visible image must be found with a powerful magnifying glass, and the *chemical* focus ascertained by repeated trials. When once found it will be the same in every case, provided the negative is placed at the same distance from the objective. The negative itself is placed in a frame at any required distance on the long mahogany board, but its plane must be perpendicular to the axis of the tube holding the objective. In Mr. Hislop's apparatus the frame is constructed so as to slide along in grooves, cut perpendicular to the axis.

The illumination may be either by natural or artificial light, but in every case it must pass *through* the negative. When using natural light, the whole system, except the side of the negative farthest away from the lens, must be inclosed in a dark box, and that side exposed to the sky. Artificial light is much less troublesome, and all the operations may be conducted in a drawing-room moderately lighted, without any of the usual photographic "messes." A paraffine lamp behind the negative, with a condenser intervening, and very close to the latter, gives very nearly parallel rays, which, without any covering to shut out extraneous light, will impress the sensitive plate in from five to forty seconds, according to the strength of the illumination and the density of the negative. We believe Messrs. Horne and Thornthwaite, of Newgate Street, London, supply the above apparatus at a trifling cost.

The collodion used to coat the plates should be absolutely structureless, otherwise a disagreeably reticulated appearance will be presented when such "pin-head" photographs are examined under the microscope. For a similar reason, pyrogallic acid, and not protosulphate of iron, should be used in the development, because the former gives a much finer silver deposit than the latter.

M. Dagron, of Paris, who has been most successful in this kind of photographic practice, uses collodio-albumen.

Milk. The milk of different animals does not appear to vary much in composition. It is composed of three principles, viz., butter, cheese (or *casein*), and whey (or *serum*).

When examined under the microscope, milk appears as a transparent fluid in which small white globules are diffused. These rise to

the surface when the milk is left at rest, and form cream, which may be removed by skimming. The globules are supposed to be the butter contained in small membranous bags, which are broken by churning. Ether has at first no effect upon these globules, but the membrane is soluble in acetic acid, and when dissolved the butter is liberated and ether readily takes it up.

Casein is a substance resembling albumen in its properties. It is soluble in an alkali, and may be coagulated by an acid. *See* "Casein."

Serum or Whey is the watery matter of milk. It contains a sugar called Sugar of Milk, *q. v.*, and also various salts.

Milk contains about 14 per cent. of butter, 14 per cent. of casein, and the remainder whey. It is either neutral or slightly alkaline, but quickly becomes acid by exposure to air, from the formation of lactic acid.

Both casein and whey are useful in Photography, but milk should not be used in any process until the cream has been completely removed by skimming. Curd or casein is produced by adding an acid, or better still, a piece of rennet, to fresh milk. *See* "Rennet."

Mordant. A class of substances used in dyeing, their effect being to cause the dyeing material to combine with the fabric to which it is applied, so that it cannot be removed by simple washing, or any ordinary treatment. Mordants are in general metallic oxides which have an affinity for the organic matter of the stuff, and by combining with it, cause the particles of the dye to combine also, and form a species of triple compound. The mordant most likely to be useful in Photography is bichromate of potash when reduced by light. This enters into powerful combination with lignin, and takes down with it any particles of carbon, or pigment, or colouring matter that are mixed with the bichromate. In this way textile fabrics may be printed by Photography.

Möser's Images. M. Ludwig Möser has described at different times in Poggendorff's "Annalen," a variety of curious experiments in which images were obtained by contact and developed by vapours in a similar way to the images in the process of Daguerre. From these experiments he has drawn certain conclusions, which are by many supposed to be erroneous. For an account of them the reader is referred to Hunt's "Researches on Light," page 248. Mr. Grove, and Professor Volpicelli have also obtained latent images capable of being developed by vapours, by means of contact aided by electricity. The account of these experiments will be found in the 2nd volume of "Photographic Notes," edited by Mr. Sutton. This

subject is one of great interest, and no doubt intimately connected with Photography; it is, however, at present involved in so much obscurity, that we think it better to refer the reader to other sources of information than to occupy space in this work with more than a brief notice of it.

Mr. M. Carey Lea has recently found that a raised image on any hard object pressed against a sensitive collodion film can be developed by the usual method with such films. These facts are very curious, and as yet inexplicable.

Mounting Prints. This consists in attaching the print, either entirely, or by its edges, to a sheet of cardboard, by means of an adhesive cement.

Of all adhesive substances, starch seems to be preferred by photographers. It should not be made too thick, and after being boiled should be strained through a cloth, and used quite fresh, as sour starch would be certain to cause the fading of the print; and if the pictures are kept in a damp place, they are apt to be destroyed by the generation of the starch fungus. Gelatine or the finest glue is undoubtedly the best cement for mounting, although its application may be a little more troublesome than other adhesive solutions.

The face of the cardboard is first damped with a moist sponge, to cause it to expand in the same degree as the print when the cement is applied to it. If this be not done, the print contracts on drying, and draws the cardboard out of shape. The print is then laid with its face upon a slab of glass, and the cement spread thinly and evenly upon the back with a stout hog-hair paint-brush. The print is then applied carefully to the damp cardboard, and lightly pressed into contact, and air bubbles pressed out with a linen rag. A sheet of cardboard is then laid upon it, and the rag rubbed over this pretty forcibly in order to ensure the perfect adhesion of the print to the mount in every part. The cardboard upon which the print is mounted is then pinned up by one corner to dry, and afterwards placed under a book-binder's press, or rolled. *See* "Rolling Press."

French cardboard is mechanically the best for the purpose, and the thicker it is the easier the operation becomes; but the bluish tint of French cardboard is very objectionable, as it contrasts disagreeably with the tint of most photographs. Cream colour is far better; and there is no doubt that cardboards might be manufactured of a great variety of suitable tints, and that the general effect of photographic prints would be greatly improved by being mounted upon such. Stereoscopic subjects should be mounted upon cardboards nearly if not absolutely black. As a general rule, a photograph should never

be contrasted with anything absolutely white, or what is even worse, of a bluish white like French paper.

Muriatic Acid. *See* "Hydrochloric Acid."

Naphtha; Rock Oil. $C_6 H_5$. A combustible and volatile liquid, resembling oil of turpentine. It occurs naturally, and may also be made artificially. As a natural product it exists in the soil at Baku, on the north-east shore of the Caspian, at Amiano in the duchy of Parma, at Zibio in the duchy of Modena, at Neufchâtel in Switzerland, at Clermont in France, at Val di Noto in Sicily, at Trinidad, Barbadoes, Rangoon, and recently in great abundance in several districts of North America. As an artificial product it is obtained from the distillation of petroleum, or the coal-oil of the gas works.

Naphtha does not congeal at 0°; it is not soluble in water, but communicates a smell and taste to it; it dissolves in absolute alcohol, ether, and oils, and is a solvent of the resins, as well as of phosphorus and sulphur in small quantities. It softens and gelatinizes india rubber, and this glairy varnish is spread upon textile fabrics to render them waterproof.

The boiling point of naphtha or rock oil varies from 180° to 600°. It is not acted on by potassium and sodium, and is used for preserving those highly oxidisable metals from the action of the air.

The naphtha above described is sometimes called *mineral* naphtha to distinguish it from wood alcohol or "wood naphtha," which is a totally different substance.

Naphtha may be economically used for burning in spirit lamps.

Natural Colours. To obtain photographs in the natural colours is, of course, a grand problem; but the probability of its ever receiving a solution is not great; and, so far, nothing has been done to inspire much hope that it may ever be accomplished. The different colours produced upon various sensitive tablets by coloured images seem, in every case, to arise from the different state of decomposition of the sensitive material, by different degrees of actinic power in the light which do not correspond with the different tints of the natural colours.

In order to produce a photograph in the natural colours, the coloured image formed in the camera must be received upon a tablet so constituted as that every colour may, where it acts, produce such an effect as that when the tablet is afterwards exposed to white light the same coloured rays may be emitted at the particular spot impressed. To discover the means of producing such a tablet really

seems to be somewhat hopeless, although certainly not impossible. (*See* also "Heliochromy."

Negative. A photograph in which the lights and shades are reversed, and the opposite of those in nature, is called a "negative." The value of a negative consists in the means it affords of multiplying positive prints in which the lights and shades are true to nature. The best negatives are those which are taken upon glass coated with a uniformly transparent and structureless film of collodion, albumen, &c.; but as glass is a costly, heavy, and fragile substance, negatives are sometimes transferred from glass to a film of gutta percha; and are frequently taken upon paper, waxed or oiled, in order to render it more evenly transparent. For a certain class of bold artistic subjects paper may be considered suitable.

The various negative processes upon collodion, albumen, paper, &c., are described under their respective heads.

Neutralization is a term used to denote the reduction of an acid or alkaline solution to that state in which it exhibits no tendency either way.

Nitrate Bath. This term is most commonly applied to the nitrate of silver solution, used for exciting collodionized plates. It should always be prepared with the purest materials, and preserved with the utmost care, otherwise failures are sure to ensue. *See* "Collodion Process."

Nitrates. These salts are compounds of nitric acid with bases. Those used in Photography will be found described under the heads of the various metals to which they belong.

Nitre. *See* "Potash, Nitrate of."

Nitric Acid; $NO_5=54$. Nitric acid is manufactured in large quantities by mixing equal weights of nitrate of potash and sulphuric acid and distilling the mixture in a retort by means of heat. Nitric acid passes over and is condensed, while sulphate of potash remains behind.

By this process a liquid nitric acid, having a specific gravity of about 1·5, is obtained, which possesses a yellow colour due to nitrous or hyponitric acid. It is purified and strengthened by redistillation with an equal weight of sulphuric acid, and allowing air to act on the distillate in a warm vessel, whereby the nitrous acid is completely removed.

Nitric acid is a powerful oxidizing agent, and forms with bases a very extensive series of salts, which are all soluble in water. The *most common* impurities found in it are chlorine and sulphate of

potash or sulphuric acid. Neither of these, however, are of any importance when the acid is used for the manufacture of pyroxyline, but they may be detrimental when it is used for acidulating the bath, and for making nitrate of silver, chloride of gold, &c. In such cases the acid should be pure, although not necessarily strong. To detect the impurities, dilute a portion of the acid with distilled water and add a drop or two of solution of nitrate of silver. If a white cloudiness appears, chlorine is present. To detect sulphates or sulphuric acid, dilute another portion and add a few drops of solution of nitrate of baryta, or chloride of barium. If no change ensues sulphates are absent.

Nitro-Glucose. This substance is made by acting on finely powdered cane sugar with nitro-sulphuric acid; the proportions being 2 ounces sulphuric acid, 1 ounce nitric acid, 1 ounce cane sugar. The pasty mass at first formed is stirred for some minutes, and it then separates from the liquid in lumps. When these are kneaded in warm water until the acidity is removed, they acquire a white and silky lustre.

This organic substance, when added in very small quantity to collodion, increases the density of the negative, and renders the film less sensitive to light.

Nitro-Hydrochloric Acid. This is a mixture of nitric and hydrochloric acids, which is sometimes called *aqua regia*, from the property which it possesses of dissolving the noble metals gold and platinum. When the mixture is heated both acids are decomposed, hyponitric acid and chlorine being evolved. The latter attacks the metal, forming chloride of gold. The best proportions for dissolving gold seem to be nitric acid 1 part, hydrochloric acid 3, and distilled water 3. After the gold is placed in it, a gentle heat is necessary before solution commences; but on no account should the temperature be raised to the boiling point, because then a great portion of the chlorine escapes instead of acting on the metal.

Nitro-Sulphuric Acid. This term is applied to a mixture of nitric and sulphuric acids, which is used in the preparation of pyroxyline.

Nitrogen. N = 14. An elementary gas. It is obtained by burning phosphorus in a closed vessel containing air, and passing the gas through lime water; or by agitating a liquid amalgam of lead and mercury with air in a closed vessel for two or three hours, when the lead abstracts the oxygen. It has neither smell nor taste, nor any action upon vegetable colours; nor is it a supporter of

combustion. Atmospheric air contains principally 1 atom of oxygen to 2 of nitrogen, in a state of mixture, not combination. Nitrogen is a little lighter than air.

Nitrogen, Oxides of. There are 5 oxides of nitrogen, viz.:—

Nitrous oxide, (laughing gas)	NO
Nitric oxide, (binoxide of nitrogen) . .	NO_2
Nitrous acid	NO_3
Peroxide of nitrogen	NO_4
Nitric acid	NO_5

Nitrogen, Peroxide of. NO_4. When two volumes of binoxide of nitrogen (NO_2) are mixed with one of oxygen, in an exhausted vessel, they combine with the evolution of heat, and form vapour of peroxide of nitrogen. This condenses into a liquid at 0°, and crystallizes at a lower temperature. The liquid is pale yellow at 32°, and deep orange at 60°; it boils at 82°; and when exposed to the air at common temperatures evaporates in yellow fumes. It is produced in nitric acid by exposure to light.

The vapour of peroxide of nitrogen is composed of 1 volume of nitrogen and 2 volumes of oxygen, condensed into one volume.

Nitrous Acid. $NO_3 = 38$. This acid is by some chemists called hyponitrous acid. It is not easily isolated. It forms salts called nitrites, none of which have any interest in Photography except the nitrite of silver; *q. v.*

Noble Metals. Gold, platinum, silver, and a few other metals, are called "noble metals," on account of their feeble affinity for oxygen, for they may remain in fusion for many hours in contact with air without becoming oxidized.

Non-reversing Slide. This is a camera slide, so contrived that collodionized glass plates may be exposed in it with the back of the plate next to the lens, and the film next to the back shutter. The best plan is to make an ordinary slide deep enough to hold two glass plates, with a space at least equal to the thickness of a plate between them; a glass plate is then to have a small triangular piece of glass cemented to each corner; the collodionized plate is laid, ...ards, in the slide, and the other plate laid with the corners ... the back shutter is then closed with its spring pressing ...he upper plate.

...-reversing slide should always be employed for taking col... ...ositives, and also for negatives when the prints are intended ...wed in the reflecting stereoscope.

Normal. The normal to a surface at any point, is the straight line perpendicular to the tangent plane at that point.

Object Glass. In a telescope, or microscope, the glass placed next to the object to be viewed is called the "Object Glass." The arrangement of lenses at the opposite end of the instrument, through which the spectator looks, is called the "Eye Piece." The glass next to the eye is called the "Eye Glass;" and that next the object glass the "Field Glass."

In an astronomical telescope, or compound microscope, there are only these three lenses.

Oils. Oils are divided into two great classes, viz., Fixed, and Volatile (or essential).

The FIXED oils are distributed largely through the animal and vegetable kingdoms. In the former the fatty matter is inclosed in membraneous cells, existing in various parts of the body of the animal; in the latter they are obtained by expression from the seed, kernel, root, bark, and other parts of plants. Fatty substances may be classified under the heads of Stearine and Oleine, the former *solid* and resembling suet, the latter *liquid* at ordinary temperatures. They may be again classified according to their property either of *drying*, or becoming *rancid* by exposure to air and light. Most oils, whether fixed or volatile, absorb large quantities of oxygen by exposure to air and light;—in the case of drying oils the effect produced is the formation of a skin or resinous varnish;—in the other case the oil is decomposed and becomes rancid and acid. Drying oils are much used in paints and varnishes.

VOLATILE oils are contained principally in various parts of odoriferous flowers, and shrubs. They are obtained in general by distillation of the dried leaves, &c., with water, and sometimes with salt and water, which raises the boiling point. The volatile oil and steam go over together, and when condensed in the receiver, the oil in most cases separates and floats upon the surface of the water. A small quantity is also dissolved in the water, to which it communicates its peculiar smell. Rose water is an instance of this. A drop of fixed oil leaves a permanent stain upon paper, a drop of volatile oil does not. Volatile oils are mostly soluble in alcohol, fixed oils are not; both kinds are, however, freely soluble in ether. When water is added to a mixture of a volatile oil and alcohol it renders it turbid. The odoriferous spirits called "Lavender water," "Eau de Cologne," "Eau de jasmine," &c., are solutions of a volatile oil in alcohol. Volatile oils combine with acetic and

oxalic acid; but with the exception of oil of cloves, they do not combine with alkalies to form soaps. They dissolve all the fat oils and the resins.

Oils are supposed to be compounds of an organic acid with glycerine as a base. When an alkali is added to the fixed oils, at a boiling temperature, the glycerine is displaced and the new compound formed is soap. Oils contain a large quantity of hydrogen. Fixed oils are bland and mild to the taste, volatile oils acrid and nauseous.

Opalotypes. Pictures on opal or porcelain glass have lately come into considerable repute, and deservedly so, for when well-executed they are extremely beautiful. The American photographers are most noted for this class of photograph.

There are several methods of preparing them, the best of which we need only here indicate, because they all depend on well-known processes. The smoothest and flattest pieces of opal glass should be selected for the purpose, and cleaned just the same as plates for negatives. The pictures may be taken from negatives either in the camera, by which means the image can be enlarged or diminished, or they may be taken by placing the *dry* sensitive plates in contact with the negative.

The finest opalotypes we have seen have been taken by Mr. Wenderoth, of Philadelphia, on albumen (*see* "Albumen Process"), and afterwards toned in gold. Collodion may be used either wet or dry, and gives excellent results; so also does the collodio-chloride of silver.

Optical Centre. Every single lens has a certain point called its optical centre; no such point, however, exists in the case of an achromatic lens, or combination of lenses. This should be distinctly understood, because ignorant persons frequently commit the blunder of speaking of the optical centre of a combination of lenses.

Confining our remarks, therefore, to the case of the single lens.

If a ray of light, incident at any degree of obliquity upon a single lens, strikes it at such a spot as that the direction of the refracted ray within the glass, produced if necessary, passes through a certain point in the axis of the lens called the optical centre, the direction of the ray after emergence will be parallel to that at incidence.

This effect is brought about by the following circumstance:—

A ray of light after refraction through a plate proceeds in a direction parallel to that which it had before. Now if the course of the ray within the glass when produced passes through the point called the optical centre, and we draw a tangent to the anterior surface of the lens at the point of incidence of the ray, and another

tangent to the posterior surface of the lens at the point of emergence of the ray, we shall find that these two tangents are parallel, so that the lens for that particular ray may be considered as a plate, and the ray does not suffer deviation by being refracted through the lens, but merely displacement.

The position of the optical centre is constant, and independent of the obliquity of the incident ray; so that in any whole pencil, no matter what its obliquity may be, which is incident upon the front surface of a lens, there is, *provided that surface be large enough*, a particular ray, *and only one*, the direction of which, after refraction, passes through the optical centre.

The optical centre of a single lens is found thus:—

If r be the radius of the front surface of a lens, s the radius of the back surface, and t the thickness of the lens, then the distance of the optical centre, measured along the axis of the lens from the centre of the face of the front surface, is equal to $\dfrac{r\,t}{s-r}$

The optical centre of a double convex lens is within the glass;—of a plano-convex lens it is at the centre of the face of the back surface;—and of a meniscus lens it is without the glass and behind it. By giving to r and s the proper algebraical sign, and a given magnitude, the position of the optical centre of any single lens may be readily found.

The use of the optical centre will be understood by referring to the figure on page 1. The focus, or circle of least confusion, of the pencil QAB is somewhere in the neighbourhood of c. Now the optical centre of the lens being within the glass, the ray QCc passes through it, and may be considered as very approximately a straight line. If then we draw this line, and set off Cc equal to the focal length of the lens, we find the point c very approximately, and without going through the laborious investigation of the bent pencil QRF.

If, in this figure, AB were an achromatic lens, the point c would be found *approximately* by considering the lens as single, or homogeneous, and of the same external form.

Organic Matter. This term is used in Photography somewhat vaguely, to denote all animal and vegetable substances which influence the action of the nitrate of silver solutions, or the developer. All organic bodies do not possess this power; only those that are readily oxidisable.

The general effect of organic matter in combination with the

reduced silver of the photographic image is to increase the density of the image when viewed by transmitted light, to redden the colour, to add surface vigour to positive prints, to diminish the chances of permanence of the photograph, and sometimes, but not always, to reduce the sensitiveness of the excited plate or paper to light.

Orpiment. As. S_3. Yellow sulphide of arsenic. Ammoniacal solution of orpiment is sometimes used as a dye. Orpiment is the basis of the pigment called "King's Yellow."

Orthographic Projection. This is a mode of representing an object in perspective, when the eye is supposed to be at an infinite distance, so that the visual rays from the different points of the object are parallel instead of converging to a point at a finite distance, as in common perspective. *See* "Perspective."

Orthoscopic Lens. *See* "Lens."

Oxygen. O = 8. An elementary gas, the name of which is derived from its property of producing acids. The atmosphere contains about one-fifth part, by *volume*, of oxygen gas, in a state of mixture; and water eight-ninths, by *weight*, in combination with hydrogen.

Oxygen is the great supporter of life and combustion. Animals, by breathing, withdraw it from the air and return carbonic acid in exchange. Vegetables, *during the action of light* in the daytime, absorb carbonic acid and return oxygen; hence the balance is maintained.

Oxygen is rather heavier than air, and when pure is tasteless, colourless, and inodorous. Its chief use to the photographer is for affording a brilliant light for exhibiting photographic magic lantern slides, or when a powerfully actinic artificial light is required in any of his operations. (*See* the following article.) The readiest mode of obtaining oxygen for this purpose is as follows:—

A copper retort, containing a mixture of about 3 parts of chlorate of potash and 1 part of black oxide of manganese (thoroughly well mixed together), is placed upon a common fire. In a short time oxygen gas is evolved. This is conveyed by an india-rubber tube attached to the nozzle of the retort into a bottle of water, called the purifier, which may stand upon the ground. After passing through the water, which cools and purifies it, the gas passes along another india-rubber tube into a large wedge-shaped india-rubber bag, which is capable of containing sufficient gas for an evening's entertainment. This bag may be filled in about half an hour, from half a pound, or less, of the mixed manganese and chlorate. When required for use, the gas bag, filled with oxygen, is placed upon the

ground between two boards hinged together, and upon the upper one weights are laid sufficient to force the gas out at the required rate, along a tube, either to the spirit lamp of the oxycalcium light apparatus, or to the point where it unites with the hydrogen jet of the Bude light.

Perfectly pure oxygen is obtained from chlorate of potash alone, and collected over mercury after having been passed through a tube containing fused chloride of calcium.

Ovalbumen. This term is used to denote the albumen derived from eggs in contradistinction to *seralbumen,* or the albumen of the blood.

Oxalic Acid. $C_2\ O_3$, HO + 2 HO. This poisonous substance is found in several varieties of plants in combination with potash or lime. The method of preparing it commercially need not be detailed here, because it is of no practical value in Photography. It is often formed in small quantities spontaneously in decomposed collodion, and is very probably one of the substances which render such collodions very insensitive. Oxalate of silver is feebly sensitive to light.

Oxidation means the combination of bodies with oxygen. Spontaneous oxidation occurs with many photographic chemicals when they are exposed to the air. Hence it is important to keep them as much as possible from its influence in well closed bottles.

Oxgall. To photographic colourists this substance is of considerable value. It can be obtained at the artists' colourmen.

Albumenised prints often refuse to take the colour applied to them. In that case a little oxgall, brushed over the print, remedies the evil at once.

Oxymel, or syrup of honey and acetic acid. This substance is best prepared for photographic use by boiling, for a very short time, one pound of honey with a pint of distilled water. Allow the solution to cool, then filter and add one ounce of acetic acid.

It was at one time much used for preserving photographic plates. They were excited and washed as usual. The oxymel was then poured on and off the sensitive surface several times, and the plates set aside to dry. This process, although good in some respects, is exceedingly slow, and has now been entirely superseded by better processes.

Ozone. Is supposed to be an allotropic form of oxygen in which it exhibits new properties. For instance, oxygen, as it generally exists in the air, has no chemical action on iodide of potassium, &c., but when converted into ozone, it decomposes them. Ether is also readily

ozonised, becoming acid, and redistillation from potash does not seem to have much effect in again purifying it.

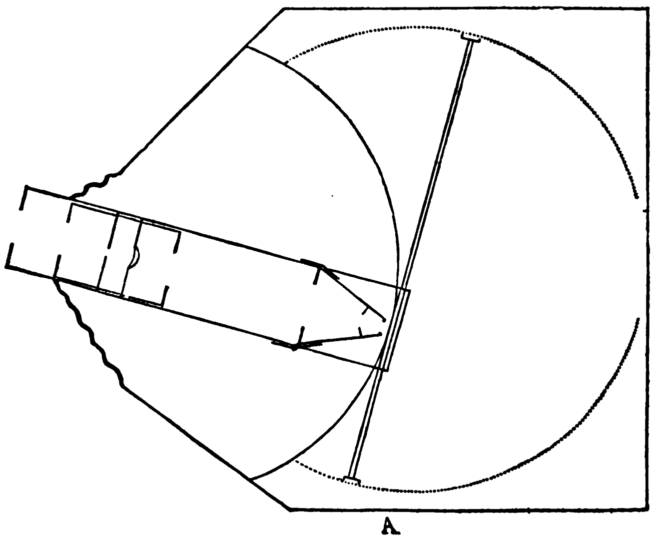
Ozone is formed when electricity is discharged into the air. It is, however, best prepared by placing a stick of phosphorus in a large bottle, and half covering it with water. Ozone will soon be generated, and may be detected by its peculiar smell.

The best method of detecting it in the atmosphere or elsewhere is by means of "ozone papers," which consist of slips of thin paper dipped in starch, and then in iodide of potassium. If ozone exists in the air these papers will turn blue by a decomposition of the iodide —the liberated iodine going to the starch and producing the blue colouration.

Oxycalcium Light. This brilliant white light is produced by passing a jet of oxygen into the flame of a spirit lamp, and directing the flame upon a small ball or cylinder of lime.

Panoramic Camera. This is a form of camera invented by Mr. Sutton, in which pictures may be taken upon one flat plate, including an angle of 90°, or more if required, without introducing the defects due to oblique pencils, such as distortion, indistinctness, &c.

The following figure will, it is hoped, be intelligible with a few words of explanation.



The lens is mounted in a long narrow tube or box, the same height as the camera. This revolves about an axis placed immediately over the stop. Inside the camera are placed two hoops, very strong and stout, one at the top, the other at the bottom of it. The dark slide always presses against these hoops. They are circular arcs, the centres of which are in the axis of rotation of the tube. The ends of the dark slide are furnished with wheels, which, as the slide is moved round, travel in grooves at the bottom of the camera, shown by the dotted lines. These dotted curves are evolutes of the lower circular hoop. The top of the lens-tube is continued till it passes over the top of the upper hoop, and the bottom of the lens tube is continued till it passes under the bottom of the lower hoop; the dark slide is then placed between these projecting ends of the lens-tube. A piece of wood lined with velvet is screwed to these ends, and, by pressing against the back of the dark slide, keeps it in its place against the hoops.

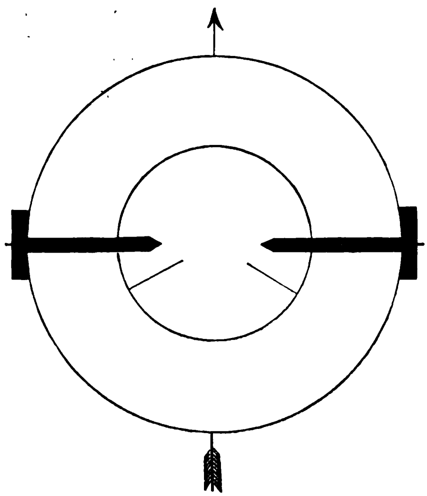
It is evident now, that as the lens-tube is turned about its axis, and directed in succession towards the different objects within the field of view, the dark slide moves with it, and is always pressed against the hoops, thus bringing the proper part of the sensitive plate opposite to the lens—the velvet-lined piece of wood sliding at the same time against the back of the slide, and the wheels travelling along the evolutes.

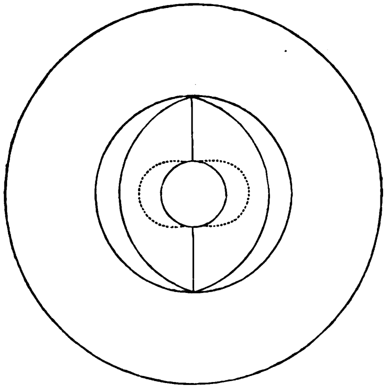
The sides of the lens-tube are furnished with folding doors, so as to diminish, at pleasure, the width of the vertical band of picture exposed at any moment; and its rotary motion may be regulated by means of a rack and pinion on the top of the camera. The shutter of the dark slide may be withdrawn, and inserted again, either through a slit in the camera at A or B. The mode of doing this may be left to the ingenuity of the reader.

The accuracy with which this instrument will do its work will depend upon the accuracy of its construction. The optical principles involve no difficulty, and the theory of the instrument is quite correct. All parts of the picture will be equally sharp, and vertical lines will not be bent out of the perpendicular. The perspective of the picture will, however, be "panoramic," and not "plane," so that the horizontal line of objects will vanish in curved and not in straight lines. If this be thought an objection, the picture may either be mounted upon a bent cardboard, or bent round a glass cylinder, and viewed in a diaphanoscope, with the eye in the centre of the cylinder. Oiled paper prints, viewed in this way, would probably be finer than anything that has yet been seen in Photography.

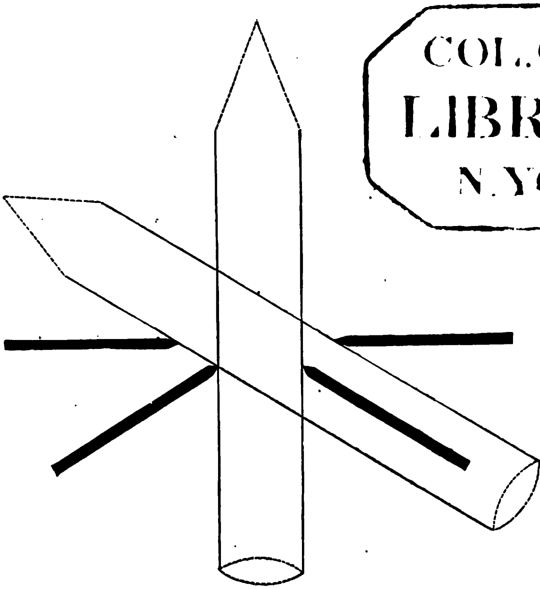
The panoramic camera would no doubt be found a valuable instrument for taking skies.

Panoramic Lens. This is a new and singular lens, invented by Mr. Sutton, and patented by him in the year 1858. It is intended for taking views which include ninety degrees or more of angular extent, upon spherical bowls, or cylindrical glasses, at one operation, and without any moveable mechanism such as that described in the former article. The lens is composed of a thick spherical shell of light flint glass, having its inner cavity filled with water, and a diaphragm placed at the centre. The principle on which it is rendered achromatic is based upon the fact, that if a lens be made with concentric spherical surfaces, so as to form a portion of a spherical shell, it will act as a concave or diminishing lens. Hence, in the compound in question, we have a concave lens made of *glass*, which has the *higher* refractive and dispersive power; and a convex lens composed of the *water* which fills the inner cavity, and which has the *lower* refractive and dispersive power. It follows, therefore, that by assigning a suitable radius to the inner surface of the shell the compound may be rendered achromatic. The calculation will be given presently, after exhibiting the general construction of the lens, which will be understood at once from the following figures:—





The curious diaphragm represented by the radiating partitions within the cavity of the lens, is for the purpose of giving as much light to the sides as to the centre of the picture; for it is obvious



that if a single round hole were used instead of this contrivance, the centre of the picture would be about twice as strongly lighted as the sides. The way in which this peculiar diaphragm acts is shown in the third figure, from which the reader will easily perceive that the most oblique pencils have the same size as the central one.

It now remains to show how to calculate the inner radius of the glass shell, so that the compound may be achromatic.

The object is to find the radius of the inner sphere so that two given lines of the spectrum may be united in the principal focus of the lens.

Let us agree to call X, Y, the lines which are to be united, so as to render the lens achromatic. Let unity be the outer radius of the spherical shell, and r the radius of the inner sphere; then r is the unknown quantity.

Let m = refractive index of line X from air into glass.
m' = refractive index of line X from air into water.
n = refractive index of line Y from air into glass.
n' = refractive index of line Y from air into water.
F = principal focal length of lens for lines X and Y, when united.

Let us first calculate F for an axial pencil of homogeneous light, corresponding to the line X.

To do this let v_1, v_2, v_3, be the geometrical focal lengths of the pencil, measured from the *centre* of the sphere, after refraction at the 1st, 2nd, and 3rd surfaces respectively.

Then, at the 1st surface we get

$$\frac{1}{v_1} = (m-1) \qquad (1)$$

At the 2nd surface,

$$\frac{m'}{mv_1} - \frac{1}{v_2} = \frac{m'-m}{mr} \qquad (2)$$

At the 3rd surface,

$$\frac{m}{m'v_2} - \frac{1}{v_3} = \frac{m'-m}{m'r} \qquad (3)$$

At the 4th surface,

$$\frac{1}{mv_3} - \frac{1}{F} = \frac{m-1}{m} \qquad (4)$$

Eliminating v_2 between equations (2) and (3) gives

$$\frac{1}{v_1}-\frac{1}{v_3}=2\,\frac{m'-m}{m'r} \quad . \quad . \quad . \quad . \quad (5)$$

And eliminating v_1 and v_3 between equations (1), (4), and (5) gives

$$\frac{1}{F}=-2\left\{\frac{m'-m}{mm'r}+\frac{m-1}{m}\right\}.$$

Proceeding in the same way with the axial pencil corresponding to the line Y, we get

$$\frac{1}{F}=-2\left\{\frac{n'-n}{nn'r}+\frac{n-1}{n}\right\}.$$

Equating these two values of F gives

$$\frac{m'-m}{mm'r}+\frac{m-1}{m}=\frac{n'-n}{nn'r}+\frac{n-1}{n},$$

which is a simple equation for determining r, so that the lines X and Y may be united, and the lens thereby achromatized.

In order to show the practical application of the above formula and the results to which it leads, let us discuss the following case which actually occurs in practice.

Let light flint glass be used, and let us suppose X to be that part of the spectrum in which the visual rays have their maximum intensity, and Y that part in which the actinic rays have their maximum intensity. And let

$$m = 1{\cdot}57. \qquad n = 1{\cdot}6.$$
$$m' = 1{\cdot}33. \qquad n' = 1{\cdot}34.$$

these quantities being sufficiently near the truth for the purpose of illustration. Substituting them in the formula above stated gives

$$r = {\cdot}53016 \qquad F = 3{\cdot}42.$$

Hence it follows, that in the case of a panoramic lens made of light flint glass and water, the inner radius of the shell is about one half the outer radius; and the focal length of the lens about $3\frac{1}{2}$ times the outer radius. These dimensions involve no practical difficulty either in making or in using the lens.

With respect to spherical aberration, that of course is reduced within practicable limits by means of the small stop, as is done in all other view lenses. If the shell of glass were much thinner, the

aberration would be positive; and if much thicker, the focal length would be greatly increased, and excessive negative aberration would be produced. Fortunately it so happens that the aberration, in passing from positive to negative, as the thickness of the shell is increased, passes through a point at which it vanishes altogether, while that point is very nearly such as gives freedom from chromatic aberration. In point of fact there is *some* negative aberration when the lens is made of light flint; but there would cease to be any if it were made of dense flint, while it would be greatly increased by making the lens of crown glass. In the latter case the focal length would be increased to six times the radius, and the negative aberration would become so excessive as to render the lens useless. On the other hand, dense flint stops so many of the actinic rays as to counteract any good effect that would result from the use of a larger stop.

The camera and printing frame must, of course, be made to suit the use of spherical bowls or cylindrical glasses, instead of flat plates. This form of surface can be easily coated with collodion, and the picture developed by the alkaline method; neither does the printing from cylindrical glasses involve any practical difficulty. Printing from spherical bowls might perhaps be effected upon silk, pressed into contact with the inner surface of the bowl; but the picture, when mounted flat, would exhibit distortion. Strictly speaking, the printing ought to be effected by means of a smaller panoramic lens placed at the centre of the bowl, and the positive should be taken upon another bowl, and viewed in a diaphanoscope. The cylindrical pictures, if mounted upon a flat cardboard, will exhibit distortion; and in order to view them correctly, the cardboard should be bent into the same curve as the negative, and the eye placed at the centre.

The Panoramic Lens is particularly suitable for taking paper negatives; because they can be easily bent to the required curve in the camera, and flattened out afterwards. A lens 4-ins. diameter and 14-ins. focus will take a picture 30-ins. long and 15-ins. wide; with the exposure required for a common flat picture 9×7, and with unsurpassed definition.

It only remains to say a word or two about fluid lenses. They have been used for the object-glasses of telescopes, and perform remarkably well. The advantage of a fluid in the interior of a combination of lenses is that it destroys internal reflexions, and prevents flare. When a fluid is used no Canada balsam is required [to c]ement the lenses together. The mounting of the Panoramic [lens] is perfectly water-tight, and the water can easily be changed, [or] the lens taken to pieces as often as is required.

The patent for the Panoramic Lens has been purchased by Mr. Thomas Ross, and he is the only maker of the instrument in Great Britain.

Pantascopic Camera. This is an instrument for taking panoramic views, including any angular extent up to 360° upon a flat plate, and with a common view lens, by means of mechanism and clockwork. It was invented by Mr. J. R. Johnson, of Red Lion-square, and is a most ingenious affair. Very successful views of Swiss scenery have been taken with the instrument, by Mr Braun, and the definition is unsurpassed. The principle of construction is not exactly the same as that described in the article on the "Panoramic Camera;" neither can it be well explained within the narrow limits of such a work as the present. The reader who is curious on the subject must be referred to the inventor himself, who will always be happy to exhibit and explain the construction of an instrument which is now manufactured by him for sale. The testimony of the writer in favour of Mr. Johnson's invention will perhaps have more weight when it is remembered that he is himself the inventor of a camera devised to answer the same purpose, and also the patentee of the Panoramic Lens. He has no hesitation in pronouncing the Pantascopic Camera a most ingenious invention, and a complete success.

Paper-Making. Paper may be made of any *fibrous* material which can be torn and beaten into pulp. The substances commonly employed are linen and cotton rags, and for coarser kinds of paper, grass and straw. We cannot in this work go at any length into the process of paper-making, but will briefly describe the mode of making hand-made paper, from which the general principles of the manufacture will be understood.

The rags are mostly imported from Germany and the different ports of the Mediterranean. They are sorted by women; torn up into shreds, and cut into pieces, then dusted in a machine, and washed, first in water, then in a strong alkaline ley, and afterwards in water again; they are then ready to be made into pulp. To effect this, they are placed with water in a machine called the "engine," where, by the rapid rotation of a complicated piece of apparatus, they are torn into the finest imaginable tatters and shreds. This is called "stuff." When the stuff is about half made, it is called "half stuff," and is then "bleached," generally with chlorine, or chloride of lime, one or two pounds of chloride of lime being sufficient for a cwt. of fine rags. This is added to the

"half stuff" in the engine, and the mixture is beaten together for an hour or so, then the bleaching liquid run off, fresh water continually added, and the half stuff reduced, by the continued action of the engine, to "fine stuff."

Sometimes the sizing mixture and colouring matter are now added, but in general the sizing is an after operation performed upon the finished sheets of paper in its bibulous state. The stuff is now run off into the "stuff chest" or vat.

Hand-made paper is made as follows:—

Two men, one called the "vat-man," the other the "coucher," stand on opposite sides of the vat, which is covered with a board or "bridge" between them. The vat is about five feet square, and four feet deep, with slanting sides, and made of wood or stone. The stuff is then diluted with warm water, and continually stirred. The vat-man takes in his hands a mould, which is the size of the sheet of paper to be made. This mould is a frame of wood, having wooden bars running across, about an inch and a half apart, and across them is laid a wire frame, the wires being from fifteen to twenty per inch; or sometimes a *wove* mould is used, covered with fine wire cloth. On the mould a "deckel," or moveable edge frame, is used to prevent the edges of the paper from being rough.

The vat-man puts the deckel upon the mould, and dips it in a vertical position to about half its depth in the stuff, then turns it into a horizontal position so as to cover it with the stuff, and gives it a peculiar kind of shake, which distributes the stuff evenly upon the mould. The mould must be held perfectly level during this operation, or the sheet will be thicker at one end than the other. The mould is then pushed across the bridge to the "coucher," who, after draining off the water, lays the surface of the pulp upon a piece of felt, to which it adheres, and then returns the mould to the vat-man. This piece of felt, with what we may now call the sheet of paper adhering to it is laid with other similar pieces in a pile, which, therefore, consists of alternate layers of paper and felt. The pile, consisting of six or eight quires, is put, and remains for some time, under a pressure of about 100 tons, to squeeze out all the water, and the sheets of paper are then removed, pressed again without the felts, and hung across a hair line to dry, in the drying-)m.

In this state the paper is bibulous, or blotting-paper, and the ;t operation is to size it.

English papers are in general sized with a mixture of gelatine , alum, to which sometimes flour, resin, and yellow soap are

added. French papers are sized with a less soluble size, consisting for the most part of starch, with a little potash.*

The sheets of bibulous paper are placed, one at a time, in a vertical position in the tub of size, and pressed into close contact. After a time the papers are taken out, scraped, and pressed to remove the superfluous size, then parted, and pressed again, and afterwards hung up to dry, a process which occupies two or three days, and must not be done too quickly. The paper is then pressed again.

The paper has now to be glazed or hot-pressed. This is done by placing a sheet of paper between two glazed pasteboards, alternately in a pile, and between every fifty pasteboards a hot iron plate, then subjecting the pile to the press. Or a pile of sheets of paper placed between pasteboards may be rolled backwards and forwards upon a plate between cold iron cylinders. This communicates a glaze to the surface of the paper.

The paper is now finished, and has merely to be trimmed, and the sheets counted and sorted, and tied up in reams, each containing 480 sheets.

The above operations of making paper by hand may be successfully imitated by machinery; the paper is then said to be "machine-made." It may be made in sheets of indefinite length.

Paper frequently contains metallic spots, consisting of particles of iron, brass, or zinc, detached from the machinery, or introduced through carelessness in sorting the rags. The roughness of the

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* With respect to the sizing of French papers. The following recipe was given some years ago by the Société d'Encouragement of Paris:—

100 kilogrammes of dry paper stuff,
12 " starch,
1 " resin, previously dissolved in 500 kilogrammes of carbonate of soda.
18 pails of water.

This size evidently renders the paper alkaline.

The following formula is given by M. Braconnot, in the "Annales de Chimie," Vol. 23:—

"To 100 parts of dry stuff, properly diffused through water, add a boiling uniform solution of 8 parts flour, with as much caustic potash as will render the liquid clear. Add to it 1 part of white soap previously dissolved in hot water. At the same time, heat half a part of resin with the requisite quantity of weak potash ley for dissolving the resin, mix both solutions together, and pour into them 1 part of alum dissolved in a little water.

This size also renders the paper alkaline. Alum has an acid reaction, and therefore English paper sized with alum and gelatine is acid and not alkaline.

felts between which the paper is pressed also occasions inequalities of texture. It is highly desirable to remove these imperfections from paper which is to be used in Photography. The practice employed by the French paper-makers of colouring their paper with artificial ultramarine (sulphide of sodium,) is also highly objectionable for photographic purposes, both as regards the appearance of the paper, and from the probability that the introduction of an alkaline sulphide into it might assist the process of fading of positive proofs.

Should the process of printing positives in carbon ever come into general use (which it is tolerably certain that it will), the imperfections now existing in paper for positives will be of less moment.

Paper, India or China. India paper, or Chinese paper, is much used by engravers for printing the first proofs from the plate. It is thin and silky, of a beautiful buff colour, and made of the fibres of the young bamboo, which are triturated, ground, and boiled to a paste. This is set to fermemt in a heap covered with mats, and the paper is then made from it. The length of the fibres renders it better adapted for receiving copperplate proofs than the best European paper. This paper is smooth on one side and bears on the other the marks of a brush which is used in the finishing process. It is made in sheets four feet long and two feet broad. When proofs are printed upon India paper no cement is used to attach the thin sheets of India paper to the thick plate paper, the mere pressure exerted by the cylinders in the operation of drawing the proof being sufficient to cause perfect adhesion between the two surfaces.

Parchment Paper. *See* "Artificial Parchment."

Paste. Mix well together flour and a little cold water, then add as much more cold water as is necessary to make the paste of the consistence required; then boil the mixture, stirring it well all the time; lastly, strain it through muslin. Starch is better than paste for mounting photographs. Sometimes powdered resin is boiled with paste to give it body, and corrosive sublimate added to make it keep. In the latter case, it is highly poisonous, and should not be left about carelessly.

Pendulum. A pendulum suspended in the portrait room may used with advantage for measuring time by seconds. The pen- m which beats seconds, that is, which oscillates in a second of (approximately), whatever be the angle of oscillation, is about inches long. If, then, a 40-inch pendulum, hanging against

the wall of the portrait room be set swinging before removing the cap from the lens, the operator, by counting its vibrations, may regulate the time of exposure as accurately as if he consulted a watch. A clock having a pendulum of that length would be a useful addition to the portrait room.

Perspective. There are two kinds of perspective delineation with which the photographer is concerned, viz., "Plane," and "Panoramic Perspective."

In plane perspective, objects are represented upon a vertical plane placed between them and the spectator. Straight lines, called "visual rays," are supposed to be drawn from the various angular points A, B, C, &c., of the objects to the eye, and where these lines perforate the vertical plane, or "plane of the picture," as it is called, are corresponding points *a*, *b*, *c*, &c., through which, if the figure be completed, it is the plane perspective representation of the objects as seen from the point occupied by the eye (not *eyes*) of the spectator. According to this definition a plane perspective view is nothing more than a plane section of the system of pyramids of which the visual rays are the edges and the eye the common vertex; the eye being considered a mathematical point. The rules of perspective, therefore, merely relate to the cutting of pyramids by a plane, and are purely geometrical, not referring in any way to the structure of the eye, or the image formed upon the retina, or the rules of optics. Perspective is nothing more than a very simple problem in solid geometry, and it is marvellous to find that so little is accurately known of it by artists, and that so many elaborate and expensive works should have been written about it, when in fact the whole thing lies in a nut-shell, as we shall now show; not, however, without calling on the reader for his patient attention, and careful study of our remarks.

Let us first suppose the object to be represented to be an infinite straight line, making an angle, ϕ, with the plane of the picture, and meeting it in the point A. Then, in order to draw the perspective view of this line upon the plane of the picture, it is evident that we should require to join the point A with some other point X. The question becomes how to find this point X. If it were possible to draw a visual ray from the eye to the end of an infinite straight line, the point where that visual ray would cut the plane of the picture would be the point X required. But is it possible to draw such a line? It is. We have simply to draw through the eye a line *parallel* to the given infinite straight line, and the point X where this line cuts the plane of the picture is found at once; for although

parallel straight lines do not meet at any finite distance, they may be considered as meeting at an infinite distance, infinite being only another term for "not finite," and the second form of the expression being identical with the first. The finite line AX is therefore the perspective view of the infinite line proceeding from A, and making an angle ϕ with the plane of the picture.

Next, suppose any number of other infinite straight lines to make the same angle ϕ with the plane of the picture, and to meet it in points B, C, D, &c. It is evident that the perspective views of all these straight lines would be terminated in a common point X, and would consist of lines AX, BX, CX, &c., radiating from X; this point X is therefore called the "vanishing point" of that particular system of parallel straight lines.

Hence we arrive at the following general rule:—

The vanishing point of any system of parallel straight lines is the point where a line drawn through the eye parallel to that system cuts the plane of the picture.

If a horizontal plane be drawn through the eye, the line in which it intersects the plane of the picture is called the "horizontal line;" and if a line be drawn from the eye perpendicular to the horizontal line, the point in which it cuts it is called the "point of sight."

Hence it follows that

1st. The vanishing point of a system of parallel horizontal lines is somewhere upon the "horizontal line" of the picture; the point being found by drawing through the eye a line parallel to any one of the system of lines.

2nd. The vanishing point of a system of parallel horizontal lines at right angles to the plane of the picture is the "point of sight."

We next come to the case of the vanishing point of a system of parallel lines which are parallel to the plane of the picture; that is, to the case in which the angle ϕ vanishes. These lines have *no* vanishing point, because the line drawn through the eye parallel to them never meets the picture. They are consequently represented by parallel lines in the picture.

Observe the practical conclusions:—

1st. All vertical straight lines in nature are represented by vertical straight lines in the picture. They do not vanish towards a point in the zenith, as is erroneously supposed. In fact, in strict accuracy, vertical lines would vanish downwards towards the centre gravity of the earth.

nd. The horizontal lines of a building which are parallel to plane of the picture are horizontal lines in the picture.

Should the reasoning by which these conclusions are established

be thought somewhat metaphysical, then we may return to the case of the section of a pyramid. Place a square board vertically behind the plane of the picture, and parallel to it. Then, since the section of a pyramid by a plane parallel to its base is a figure similar to the base, the perspective view of the square is also a square; that is, neither the vertical nor the horizontal lines have any vanishing point.

We have now discussed the whole theory and mystery of plane perspective. If the reader has carefully followed our reasoning he will not require to spend his money in treatises on perspective, (which are generally full of gross blunders), but may trust to his own good sense to apply the rules which we have established.

The following remarks should be borne in mind :—

In views of marine scenery, the horizontal line is always higher than the sea line, because of the dip of the visible horizon; and the sea line is a curve convex to the horizontal line, and most nearly touching it in the point of sight.

The perspective view of a sphere is an ellipse in every case, except that in which the line joining the eye and the centre of the sphere is perpendicular to the plane of the picture, so that the centre of the sphere is on the point of sight. For let a visual ray travel round a sphere, it sweeps out a *cone* with a circular base, and the *oblique* section of such a cone is an *ellipse*.

If the plane of the picture be inclined to the vertical, vertical lines have a vanishing point either above or below the horizontal line.

The reflections of vertical objects in water are vertical, and have no vanishing point, because the image of a vertical line is in the vertical produced *beneath* the surface of the water, and not in a horizontal line lying *upon* the surface of the water, as it appears to be. When the reflection of a vertical line is not represented as a continuation of that line, but as making an angle with it, the perspective is incorrect, no matter in what part of the picture the vertical line may be, or how situated with respect to the point of sight. The reflection of an object which is out of the perpendicular is not necessarily in the same straight line with it, but in general makes an angle with it.

The reflection of the sun or moon is always vertically under it, no matter where the point of sight may be. Also, the bar of light produced by the reflection of the sun or moon in rippling water is always vertical, and does not appear to approach the spectator, as it is incorrectly represented to do in many pictures.

Some of the above remarks may be received with surprise and incredulity by some readers, but a little consideration will show that they are strictly correct.

Panoramic Perspective is when the picture is represented upon a sphere, or vertical cylinder, of which the eye is in the centre. In this kind of perspective the rules are somewhat more complicated, and need not be stated in this work; it will be sufficient to observe that, in a panoramic picture flattened out, straight lines vanish in curves, not in straight lines.

When the image is formed upon the focussing screen of a camera having a small pin-hole in front instead of a lens, it is in perfectly true perspective; for if we consider the pin-hole as the vertex of the system of pyramids formed by lines drawn from it to the objects, and that these lines are produced *through* the hole so as to form another system, equal and similar to the former, but inverted, it is evident that the section of this second system made by the focussing screen is equal and similar to a section made by a screen placed symmetrically with it on the opposite side of the pin-hole, and therefore equal and similar to a perspective view obtained in the ordinary way, but inverted.

Phosphori. Bodies which emit light in the dark, after having been exposed to light, are called "solar phosphori." When we consider that bodies which have been exposed to heat continue to radiate heat for some time after being removed from the source of heat, and that heat and light are most probably undulations in the same ether, differing only in the length of the wave, the existence of solar phosphori cannot be considered a remarkable phenomenon; on the contrary, the wonder is that so few bodies should exhibit the property possessed by them.

The first solar phosphorus on record was discovered about the year 1630 by Cascariolo, a shoemaker of Bologna, who found that calcined sulphate of baryta was luminous in the dark after having been exposed to sunshine, and that it continued luminous for some hours. The matter speedily assumed importance, and considerable quantities of calcined Bolognian spar (the native sulphate employed) were sold as an article of curiosity.

"Canton's phosphorus" is another example of the property. It is made by first calcining oyster shells in the open fire for half an hour; then selecting the largest and whitest pieces, mixing them with about one-third their weight of flowers of sulphur, pressing the whole into a crucible with a closely luted cover, and keeping it at a
·at for an hour. The contents when cold may be turned out
e best pieces selected. They will be found to shine in the
fter having been exposed to sunshine.

ate of lime fused at a dull red heat is also a solar phosphorus.

The blue and violet rays appear to be most effective in producing the phosphorescence. It is not found that solar phosphori generally emit light of the same colour as that to which they have been exposed. There are phosphori from heat as well as from light. The native phosphate of lime found near Estremadura, in Spain, and also some varieties of fluor spar, particularly one called "chlorophane" are the most remarkable instances. These become luminous when slightly heated, or by friction.

Some animal substances are spontaneously phosphorescent. The flesh of the tench, carp, herring, and sole is luminous before putrefaction commences. The property is rarely possessed by the flesh of quadrupeds, and has never been observed in that of birds. The phosphorescence of the sea is a beautiful phenomenon frequently observed, but one which has not yet been accounted for. It is probably due to the presence of phosphorescent animal matter.

The glow-worm and fire-fly are familiar instances of phosphorescence possessed by living animals.

Decayed wood and certain mosses have been known to exhibit phosphorescence, but the property is rare in the vegetable kingdom.

Some salts, (sulphate of potash for instance,) emit light during crystallization.

Phosphoric Acid. $PO_5 = 71$. This acid is used in a diluted form in Willis's aniline process. It may be prepared by pouring 4 fluid ounces of nitric acid, and 8 ounces distilled water on 6 drachms of phosphorus in a retort, and applying the heat of a sandbath. The distillation should proceed till the residue in the retort is of a syrupy consistence. The syrup is then poured into a platinum vessel and heated to a dull red. It fuses and concretes on cooling into a transparent mass. This is glacial phosphoric acid, which may be diluted to any required extent.

Phosphorus. $P=31$. This remarkable elementary body is contained in the bones and fluids of animals, and also in the vegetable and mineral kingdoms. In bones it exists as phosphate of lime, and is obtained from them by acting on calcined bones with sulphuric acid, and distilling the superphosphate of lime thus produced with the addition of charcoal. The phosphorus, which is volatile, passes over, and its vapour is condensed and drops into water. It is at first a soft translucent yellowish white substance, but becomes red by exposure to light, which is supposed to afford an instance of allotropy. It is insoluble in water, but soluble in oils and in ether.

Phosphorus is highly combustible, and burns slowly and spon-

taneously in the air, but magnificently in oxygen. It should be kept, and cut, under water. Its chief use is for making lucifer matches.

Photo-Galvanography. This is a process for producing copper plates ready for the printer, by the joint action of light and electricity. A company was formed at Holloway, in 1856, for carrying out the process, under a patent obtained by Herr Pretsch, who superintended operations.

We paid a visit to the establishment in November of that year, and Herr Pretsch was kind enough to explain the various stages of the process. We subsequently wrote the following article in "Photographic Notes," No. 15, describing what we had seen and heard.

"A positive photographic print is first taken,—generally on paper. In order to produce from this a copper plate the following operations are employed:—

"First;—A sheet of glass is coated with gelatine containing bichromate of potash and other chemicals. When dry, the positive is laid upon it, face upwards, and it is exposed to light in a pressure frame for a few hours. The time of exposure of course depends on the intensity of the light. Sunshine is preferred, but is not necessary. The picture upon the gelatine is developed in raised and sunk parts by immersion in a fluid, the principal constituent of which is water. Where the light has *not* acted, the gelatine swells and forms a ridge, or a series of minute granulations. Where the light *has* acted, the gelatine is hardened and does not swell. The picture upon the gelatine is very curious, and resembles a positive by reflected light, the shadows and dark parts being rough and the lights smooth and polished.

"Second;—A mould of the picture upon the gelatine is taken in gutta percha. This mould is an intaglio picture, precisely resembling the finished copper plate. The gutta percha mould is about half an inch thick.

"Third;—A copper plate is made from the gutta percha mould, by means of the electrotype process. This part of the process is very slow, occupying perhaps a week or two. The copper plate thus obtained is called the matrix. It precisely resembles the original gelatine picture.

"Fourth;—The copper plate from which the proof is to be printed now obtained by the electrotype process from the matrix. This is slower process than the last, because the copper is much thicker. occupies about three or four weeks.

"The entire process therefore occupies about six weeks. From

the final plate four or five hundred good impressions may be struck off in the ordinary way;—a considerable number of plates may be obtained from the matrix;—a considerable number of matrices may be taken from the gutta percha mould; and a considerable number of gutta percha moulds from the gelatine picture. Here then are the means of almost indefinite multiplication. Some idea of the number of proofs which might be obtained from the original gelatine picture would perhaps be got by multiplying 500 by itself four times. This gives more than sixty thousand million impressions; that is, sufficient proofs for six times the present population of the earth. The most elaborate subjects may be engraved by this process in as short a time as the simplest, the amount of detail in a photograph or photo-galvanograph making no difference, for light, chemistry, and electricity do the work. The time at present required for any subject is a few weeks; the time frequently spent on engravings is two or three years."

The company has ceased operations, probably from the process not being in a sufficiently perfect state to render it independent of the help of the engraver for retouching the plates. This is much to be regretted, because the process is perfectly suitable for a class of bold artistic subjects which, taken from nature by Photography and multiplied in printers' ink, would be of great service as studies for artists, or copies for drawing masters to lay before their pupils.

Photogen, Moule's. A lantern, fitted with a chimney and reflector, and adapted for burning Bengal Fire, or other suitable chemical compound, in the portrait room at night, so as to enable the photographer to take portraits by artificial light. It has been patented by Mr. Moule.

Photography is a term used to denote all sorts of pictures which are taken by the action of light on chemical compounds. Its literal meaning is "the art of writing by light."

The alchemists discovered the fact that "Horn silver," *i.e.*, chloride of silver, was blackened by exposure to light, but their observations led to nothing practical.

Scheele, in the year 1777, was the first who examined the decomposing effects of light on silver compounds; but it was left for Wedgwood and Davy, about the year 1802, to apply the now known fact to artistic purposes. They threw the *shadow* of the object which they wished to copy on a piece of paper impregnated with nitrate of silver, thus obtaining a white image on a black ground. They found *leather* the most sensitive medium. Now, it is very

remarkable that these distinguished philosophers did not at once discover the great fact which Mr. Reade and Fox Talbot afterwards found out, which is the basis of almost all modern Photography. Leather contains tannin or gallic acid—this was the secret of the greater sensitiveness of leather, but they failed to comprehend its full significance.

The sensitive surfaces prepared by Wedgwood and Davy were not sufficiently sensitive to receive an impression in the camera, although it would appear the attempt was made. Davy, however, succeeded in obtaining a faint image in the solar microscope.

Till the year 1814 we find no record of further progress in Photography, when Joseph Nicéphore Niépce perfected a camera process which he called "Heliography." In this process he discarded the use of salts of silver, and used as his sensitive medium a resinous substance called "Bitumen of Judæa." The resin was spread over the surface of a metallic plate, and exposed to the actinic rays, either under a picture or in the camera. The same process has now been applied by Mr. Pouncy, of Dorchester, to carbon-printing from negatives. By exposure to light, the resin, when acted on by the actinic rays, changes its properties and becomes insoluble in turpentine and other solvents which usually act upon it. After some hours' exposure in the camera, the resin-coated plate was removed and steeped in any of the solvents of asphaltum or bitumen of Judæa, which dissolved away the resin where the light had not acted. The shadows were represented by the surface of the plate where the resin had been dissolved, and the lights by the unaltered resin. There are several specimens of Niépce's original process in the British Museum, some of which also show his attempts at etching by the same process.

Some ten years later, Niépce and Daguerre, the latter of whom had been working in another direction, became acquainted, and mutually experimented in the photographic art. Daguerre had previously been directing his attention to the salts of silver as the sensitive medium; but it was not till the year 1839—after the death of Niépce—that the daguerreotype process was published. In it the sensitive surface was iodide of silver on a silver plate, and the developer vapour of mercury, which is much the same process that is now employed, although, by means of bromide and other appliances, its sensitiveness was subsequently much enhanced. Daguerre also succeeded in fixing his proofs by means of hyposulphite of soda, a salt which was discovered several years previously by Sir John Herschel, and its properties described by him in the "Edinburgh Philosophical Journal." *Its importance* in photographic operations is now thoroughly appre-

siated, and no salt equal to it in value for *fixing* purposes—although several others have been suggested—has yet been discovered.

In the same year—viz., 1839—that Daguerre published the details of the daguerreotype process. Mr. Fox Talbot, in the month of January, communicated to the Royal Society a memoir relating to the preparation of a more sensitive paper than had hitherto been employed. He first dipped the paper in a weak solution of chloride of sodium, and afterwards in a stronger one of nitrate of silver. By this method a sensitive medium was obtained, on which leaves of plants, engravings, and other unequally translucent subjects could be copied in reverse, by pressing them against the sensitive surface, and allowing the light to pass through the leaf, &c.

These reversed copies, or negatives, could be used again to produce, by the same means, natural representations of the objects copied. Mr. Talbot fixed his pictures with a concentrated solution of common salt: which shows most clearly that, at that time, he had borrowed nothing of his discovery from Daguerre, nor from the researches of Herschel on the hyposulphites, published in 1821.

Two years later—in 1841—Mr. Talbot patented a process, called the "Calotype," by which an invisible image impressed in the camera by a very short exposure to light, could be *developed* into a *negative*, from which any number of *positives*, or naturally-lighted pictures, could be printed on the silver-chlorized paper. This process, which is the foundation of all modern Photography—excepting Mr. Willis's "Aniline Process"—consists in imbuing a sheet of paper with iodide of silver, which, when exposed for a very short time to light, although seemingly unchanged, is energetically acted on by deoxydising agents, such as gallic and pyrogallic acids, proto-sulphate of iron, &c. These developing agents decompose the nitrate of silver with which they are conjoined, and deposit the metallic element only on those parts which have been affected by the light; and the density of deposit is proportional to the actinic impression. To equalise the energy of the developer, it was soon found necessary, even in those early days of Photography, to restrain it by means of a weak acid, such as acetic, &c., otherwise the silver would be reduced on those parts of the iodised paper which had not been actinically impressed. Mr. Talbot's process (*see* "Calotype"), has not been much improved upon since he first published it.

It is doubtful whether Mr. Talbot or the Rev. T. B. Reade is the real discoverer of the modern photographic negative process. In 1839, two years before Mr. Fox Talbot patented his invention, Mr. Brayley, Librarian of the London Institution, described in a

lecture delivered to the members, a similar process communicated to him by the Rev. T. B. Reade. The truth seems to be, that Mr. Talbot got the hint of *gallo-nitrate of silver* from the late Andrew Ross, the celebrated optician, to whom Mr. Reade had mentioned its powerful action on iodide of silver exposed to light. The only point on which Mr. Talbot seems to have improved on Mr. Reade's suggestion is in the employment of acetic acid in the gallic developer.

The next stage in the history of Photography is the employment of glass plates to receive the medium on which the negatives are impressed. Sir John Herschel was here first in the field, but his suggestions were not practically carried out—at least to any great extent —till the year 1847, when Niépce de St. Victor, the nephew of Joseph Nicéphore Niépce, who was associated with Daguerre in the daguerreotype process, proposed the use of *iodised albumen films* on glass, and succeeded in obtaining good negatives thereby. Immediately after this process was published, photographers in Britain and elsewhere set to work and produced some of the finest photographs, which, with our modern appliances, have not to this day been surpassed. The Messrs. Ross and Thompson, of Edinburgh, and Mr. Robertson, of Constantinople, in particular, have signalised themselves by their large and beautifully artistic photographs taken by this process.

We come now to the "collodion process," which is the foundation of what may be called the truly commercial phase of Photography. M. Le Gray, of Paris, in a little work on the waxed paper process, first suggested the probability of its being useful as a vehicle for the sensitive iodide of silver, but it was reserved for the late Mr. Archer, of London, to carry out this idea practically. No one now knows whether M. Le Gray's suggestion ever reached Mr. Archer's ears; most probably it did not, because in that same little publication of Le Gray's all sorts of things were mentioned as vehicles for the iodide. Mr. Archer's communication appeared in the "Chemist" in the autumn of 1851. In the same paper he also proposed the use of pyrogallic instead of gallic acid, as a developer. Since that time collodion has been almost universally adopted as the medium for photographic negatives, the only improvements on the original formula being modifications of manufacture and of development, whereby much greater sensitivenes has been obtained.

Parallel with the above photographic discoveries were others in a different direction, to some of the most important of which we can but just allude. Mr. Mungo Ponton, in the year 1839, announced to the "Royal Scottish Society of Arts" that bichromate of potash *might* be used to sensitise paper. The parts exposed to light

became of a dark orange tint, which was insoluble in water, while the yellow colour, not acted on by light, could be removed by washing.

The full significance of this discovery was not appreciated till Mr. Fox Talbot subsequently showed that it was only in combination with organic matter that this salt was sensitive to light at all. In the year 1852 he took out a patent for the use of bichromate of potash and gelatine for a new process of engraving on steel. This is the foundation of almost all the photo-engraving and photo-lithographic processes of the present day.

In 1855, M. Poitevin patented a carbon printing process, founded on the same principle. He dabbed over a sheet of paper a mixture of bichromate of potash, gum-arabic, and finely-divided charcoal. When dry, it was exposed to light under a negative and placed in water. The parts unacted on by light were washed away, leaving the white paper exposed; the rest remained unchanged. This, again, is the foundation of all the carbon printing processes of the present day, except Mr. Pouncy's, which depends on the sensitiveness of bitumen of Judæa to actinic radiations. Considerable discussion has taken place as to who was the first that ever could show a presentably good photograph in veritable carbon. There can be little doubt but that our countryman, Mr. Pouncy, was the first who could do so.

Upon the same bichromate salt, combined with gelatine, depend the different photo-lithographic and photo-zincographic processes. The most important modifications of the former appear to have been invented by M. Asser, of Amsterdam, and Mr. Osborne of Australia, independently. Mr. Osborne's process was patented in 1859. In the winter of the same year, Col. James, of the "Ordnance Survey Office," Southampton, transferred to zinc a chromo-carbon print, which was the first photo-zincograph ever executed.

Herr Pretsch, of Vienna, many years ago applied a bichromate salt with gelatine to a process which he called "Photo-galvanography" (*q. v.*). Many pictures printed by this process were issued in this country. The photo-relief processes of Mr. Swan, and of Mr. Woodbury, are only modifications of this.

There are many other photographic applications of various salts which are of some importance and interest, which will be found described under their respective headings.

Photo-Lithography. M. Poitevin seems to have been the first who made attempts in this direction as early as 1856; but his process, although the key to all others, possessed many disadvan-

tages. Mr. Osborne, late of Melbourne, has brought it to a high state of practical efficiency, and published in a paper read at the "Franklin Institute," U. S., the working details, which are as follow:—

"My process is designed for the reproduction of line drawings and engravings of every description, and the substance upon which I work and from which I print is lithographic stone. The problem I had to solve may be stated as follows:—*From a given original existing as a black and white delineation, to produce by the chemical properties of light a facsimile upon stone, identical in character with an ordinary lithographic drawing, which has been by the necessary preparation fitted for the printer.*

"Before proceeding to describe the way in which this is accomplished, it may be well to state, for the better elucidation of my subject, that lithographic stone consists of a certain variety of carbonate of lime, which is found in the celebrated Solnhofer quarries, in Bavaria, and is exported to this and other countries in the form of slabs a few inches thick, and of various sizes. For use, one surface of such a stone is ground smooth and level, and sometimes polished, and upon this the artist executes his work. If a line be drawn upon such a surface with a pen dipped in a peculiar ink, the essential characteristic of which is that it contains fatty matter in solution; or with a crayon made with a mixture of fat, wax, and resinous substances coloured with lampblack; or if we bring in any other way a greasy line upon the stone, and having done so subject the whole surface to the action of a slightly acidulated gum water, the face of the stone so prepared will be found to have undergone a change, and to have acquired certain remarkable properties which it did not possess before; in fact we have produced a true lithographic drawing, and from the line above mentioned we can now print impressions in the press. The changes which have taken place by the action of the fatty matter, acid, and gum, upon the carbonate of lime are rather complex: they are for the most part little understood and indifferently explained. The subject is indeed a difficult one, and an exhaustive examination of the phenomena which present themselves in lithography would form an important and extensive treatise. On the present occasion I must content myself with stating in general terms that the printing capabilities of a lithographic drawing, after "preparation" or "etching," as it is called, depend upon the adhesive attraction which those parts of the surface constituting the drawing manifest for greasy matter brought in contact with them, and the repulsion of the same for water. They depend *still further* upon the converse of this state of things over the rest

of the face of the stone, such portions having a strong affinity for water, and when wet as strong a repulsion for grease. Thus a sort of antagonism is set up, and the surface of the stone is, if I may be permitted to use the expression, polarised, as far as its adhesive affinity for grease and water is concerned. This change in physical properties is due to the chemical combinations which have taken place; these, as before stated, are difficult to account for thoroughly, but it will suit our present purpose to bear in mind the leading fact, which is this:—that a portion of the greasy matter contained in the lithographic ink enters into combination with the lime of the stone, forming a new substance with it, the boundaries of which are sharply circumscribed. This substance is an insoluble lime soap, and it is neither raised above nor depressed below the face of the stone, and yet constitutes the printing surface, the production of which is the aim of both the lithographic and photo-lithographic artist.

"To obtain a proof on paper from a stone in this condition the following method is employed:—The stone is first evenly damped with a sponge or cloth. The printers' roller charged with ink—a compound of prepared oil and lampblack—is then passed backwards and forwards over the work, whereby it deposits its ink only on the design or drawing, for the moisture on the other parts of the surface hinders its adhesion to them, and causes them to remain perfectly clean. A sheet of paper is next laid upon the stone, which is then drawn through the press; this sheet is then lifted off, and it will be found that the pressure has caused the accumulated ink upon the stone to attach itself to the paper, and produce there the desired impression. These operations are repeated for the next sheet, and so on until the requisite number is printed.

"The foregoing very imperfect sketch of lithographic general principles has served at least to define what the end and aim of the photo-lithographer should be. What I have now to describe is the means whereby the hand of man may be dispensed with, and its place supplied by photographic manipulations.

"Let us suppose that a map has been compiled and drawn with great care, and that it is desired to multiply copies of this original in the lithographic press. The first step in the process is to obtain a negative, for which purpose the map is placed upright upon a plan-board, and the camera opposite to it at such a distance as to give the desired ratio between original and copy. A negative is now taken on glass coated with collodion quite in the usual way, save that the greatest care is observed to avoid distortion of all kinds, and to produce a negative of the highest excellence, success

in which depends entirely upon the knowledge, judgment, and experience of the operator.

"A sheet of plain positive photographic paper is now coated on one side with a mixture consisting of gelatine, softened and dissolved in water, to which a quantity of bichromate of potash and albumen has been added. The paper, evenly covered with this fluid, is dried in the dark, when it will be found possessed of a smooth glassy surface, and a brilliant yellow colour. This surface is still further improved by passing it through the press in contact with a polished plate.

"A suitable piece of positive photo-lithographic paper thus manufactured is now to be exposed to the action of the light under the negative of the map already described. This is accomplished in an ordinary pressure-frame, the time required varying from ten to fifteen seconds to several minutes, according to the brightness of the weather; but it is always short compared with that necessary for the production of a picture on paper prepared with chloride of silver. The positive thus obtained presents itself to the eye as a brown drawing upon the clear yellow of the sheet. If the prepared surface of the paper were now moistened with water, and the attempt made to apply printing ink to it, we would find a strong tendency in the albumino-gelatinous surface to behave towards greasy and watery substances in a manner quite analogous to that already stated as peculiar to a lithographic stone while printing. We would also find that the solvent action of water at any temperature is quite incapable of removing the picture which the sun has imprinted upon it. The light, in fact, has so acted upon the chemical substances brought together upon the surfaces of the paper that the organic matter is no longer soluble. These are the characteristics of the change due to exposure which we have to remember.

"But the exposed photographic copy of the original is not moistened, or subjected to any solvent action at this stage of the proceedings; it is, on the contrary, covered all over, while dry, with a peculiar lithographic ink known as transfer ink, which is accomplished by running it through the press with its face in contact with a stone which has already received a coating of such ink. After it is separated from the blackened stone it will be found to have brought away with it an evenly distributed film of inky matter forced by the pressure into intimate contact with the unexposed as ell as the exposed portions of the surface. This operation is nown as "*blacking*" the positive print; that now to be described called "*coagulation*," its object being to effect a change of that ature upon the albumen contained in the coating of organic matter.

For this purpose moisture and heat are necessary, and both are applied very simply by letting the blackened photographic copy swim upon the surface of boiling water with its inky side upwards, for it is important not to wet that with hot water. After the lapse of a certain period, determined by the experience of the operator, he proceeds to the next step in the process, that of "*washing off*." For this purpose the print is laid upon a smooth surface, such as a plate of glass or porcelain, and friction with a wet sponge or other suitable material is applied to the black inky coating, under which the photographic image still exists, and to develop which is now the object in view. The operator soon becomes aware that the moisture which percolated through the paper from the back has exerted a softening or gelatinising influence upon the gelatine in the sensitive coating; it has caused it to swell, and to let go its hold upon the ink. But this change does not extend to those parts of the coating which were acted on by light; in other words, to those places which were unprotected by the opacity of the negative they remain intact, uninfluenced by the solvent or moistening effect of the water. Accordingly, the operator finds a *facsimile* of the original map gradually develop under his hand as he continues the friction. This process is proceeded with until all traces of ink are removed save those required to form the picture, which must be clear and distinct in all its details. Abundance of hot water is then poured over it, so as to remove every particle of soluble matter, and it is then finally dried, which completes its preparation. We are now possessed of a photograph in lithographic ink, identical in every respect with the original, not simply upon paper, but upon albumenised paper—a matter of much importance, as will be presently explained. The presence of the albuminous layer under the picture is the result of the coagulation which took place while the print was swimming on the hot water; after that change no amount of washing could remove it, although the gelatine was not proof against such treatment.

"A stone to which a fine smooth surface has been imparted is now slightly warmed and put in the lithographic press. Upon this is placed inverted the positive print, after it has been damped by lying between moist paper, and the whole is then passed repeatedly through the press. On examination, the paper will now be found to have attached itself firmly to the stone, so that some force is required to separate the two. When the former is removed it brings with it the albuminous coating, which gives to it its while damp a parchment-like appearance. But the ink is gone; it has left the paper for the stone, and on the latter we find a reversed drawing of the

map, one which, after it has been properly "prepared," will print as well as if it had been drawn by hand. The *rationale* of this method of transfer is easily understood: the greasy ink having a great affinity for the substance of the stone, combines with it to form a lithographic drawing in the strictest sense of the word, and while this is taking place the damp albumen upon the paper holds the sheet in its proper place, so as to prevent a shift of any kind, and enable the pressure to be applied as often as the operator wishes.

"I have thus overcome the difficulties of the problem I undertook to solve; I have succeeded in making light do the work of the lithographic artist as far as copying the original is concerned. The printer can now multiply impressions from such a stone with as much facility as if the drawing upon it was of ordinary and not of photographic origin."

Photomicrography. This term is used to denote the art of taking *enlarged* photographic pictures of microscopic objects.

Many microscopists, both in this country and in America, have been very successful in this branch of Photography. Dr. Maddox's pictorial enlargements, in particular, are wonderfully fine, and leave nothing to be desired. It is needless for any one who is not well acquainted with the manipulations of Photography, and well versed in the method of using the microscope with the different kinds of illumination, to attempt this branch of the art. A first-rate instrument is also a *sine quâ non.* From a paper read by Dr. Maddox at a meeting of the North London Photographic Association, we extract the following details of his *modus operandi* in producing the splendid results which he has obtained.

"The instrument is supported at some distance from its centre on three double, strong legs. The mirror is removed, and one of Abraham's achromatic prisms substituted. The stage slides along the support of the microscope, and carries a revolving disc or diaphragm with a tube screwed to one of the apertures. In this tube slides another, carrying a Coddington lens. The slide of the stage has a traversing motion by tangential screws. The arm carries adapters to receive different objectives. A fine screw, with graduated milled head, surrounded by a spiral spring, passing through the axis of the body or pillar, and acting on the arm, forms the slow motion, while the coarse adjustment is made by altering the position of the stage. One-half of the microscope tube, which unscrews in the middle, projects from the near surface of the arm: this is at once received into a wide, stout card-board tube, lined with dull

black paper, through one end, closed with a centrally-pierced cap of leather. This tube is divided into two parts, having a telescope motion, connected together by a sliding joint made to fit on one, and carrying from *its* edge a thick circular flap or ring of black cloth, which passes over the end of the other tube, and effectually closes the telescope part against the admission of light. At this juncture a diaphragm can, if needed, be introduced. The other or near end of the card tube is fixed on the brass tubing of a half-plate portrait combination, the lenses being removed: this fits to the front of a camera, and between the front and back part of which is a collapsing portion. A long screw unites the sliding body to the other for the facility of ordinary use in focussing; and the parts of the camera are kept central with the microscope by wooden guides at the sides. The front portion or body of the camera can be fixed beneath by the screw that belongs to the ordinary triangle. A thick velvet collar slides on the microscope tube, up to and against the leather cap, to shut off the entrance of any light.

"Let us suppose an appropriate object selected. It is first, *if not well known*, carefully examined with the compound microscope and the object-glass to be employed; the corrections for the thickness of the glass cover made, if needed; and some part in view selected as that furnishing the best general idea of the object. It and the objective are then removed to the micro-camera, centred, and focussed. Now becomes apparent the value of the prism, which is so turned (using direct sunlight) as to obtain, when looking on its surface, an image of the object-glasses carried back by the Coddington lens. When these are included in the sun's image, and the illumination in the glass screen is perfectly equal, a very minute alteration of the prism sends the rays obliquely to the Coddington lens and to the object. The screen is again examined, and if the character of the image shows the shadows to be too great, the prism is again moved until it furnishes a good general appearance. This slight movement often brings suddenly into view a fine line or some markings not previously noticed. The image is now viewed with a moderate magnifying power fixed in a tube, so that its focus corresponds to the far side of the greyed glass. A difficulty sometimes meets us here that is very troublesome when the weather is cold. We often require to go fairly over the entire image with the eye, and if this occupy any time the breath is apt to condense on the near side of the screen, our view is rendered imperfect from the refraction caused by the vapour, and the lines appear confused. This especially happens when the covering cloth is drawn close to exclude light. So troublesome did I find this at one time that I entirely set

aside the aid of the magnifying lens, and trusted to the eye suddenly catching some fine marks or lines. The Coddington lens I have employed, not for any optical value it possesses over an achromatic lens, but from its construction as part of a sphere I find it gives a very equal illumination, and is less likely to be injured by the heat rays in the focus of the prism. It naturally lessens the effective optical angular aperture of the high powers; but I do not find this a disadvantage. The prism is placed at such a distance, when used with the Coddington lens, that its focus would just pass the surface of the object were it used alone. In this way it fills the condenser; but if used without the latter, which is occasionally the case, I prefer the rays to have crossed before reaching the surface of the object, as there is less chance of their injuring the objective by loosening the medium used in cementing the lenses."

Collodion is the best medium to use. The common bromo-iodised collodion, now generally adopted and developed in the ordinary way, is all that is wanted. Then as to the proper time of exposure, that must be determined experimentally; experimentally also must the allowance be made for the difference between the visual and chemical foci in microscopic objectives, which are always over-corrected. They project the violet or chemical rays beyond the others. Hence it will be always necessary, when the visual focus has been sharply obtained, to move the object glass, by means of the fine adjustment screw, slightly away from the object, before a sharply defined *photographic* image can be obtained. The requisite distance depends on the power of the objective used and, strange as it may appear, on the mode of illumination. The distance is, of course, greatest with the low powers. For instance, Mr. Shadbolt found that an inch and a half objective required to be moved one-fiftieth of an inch; a two-third objective, one two-hundredth of an inch, and so on for higher powers.

The best modes of illumination are either sunlight or bright diffused day-light, but Dr. Maddox has shown that the combustion of magnesium wire offers a tolerably good source of illumination when the solar rays are not available. Under such circumstances a condenser is necessary.

Photo-relief Printing (Woodbury's process). This name is given by its inventor to a process for obtaining pictures from an taglio in relief by pressure. Mr. Swan, of Newcastle, also inated contemporaneously with Mr. Woodbury, a similar process. e principles upon which both processes are based will be scribed briefly, because the practical results aimed at have

not as yet fulfilled the sanguine expectations of the inventors.

A *raised* photograph on a surface of bichromated gelatine on talc is obtained from a negative in the usual way. From this picture in relief an electrotype cast is made by means well known to electrotypists; or another method is adopted of laying the raised gelatine picture face upwards, and still attached to the talc, on a perfectly flat bed of iron, and placing over it a plate of type or other soft metal. This is now subjected to heavy pressure in a hydraulic press, which forces the dry gelatine into the type metal, thus forming an exact transcript in reverse of the relievo picture. To print from the intaglio mould obtained by either of these two processes, a small quantity of a warm solution of gelatine containing any desired colouring matter is placed on the mould, the paper or glass is laid on it, and the whole subjected to pressure for a minute or two till the gelatine sets. The paper is then stripped from the matrix, when the image will be found imprinted on its surface.

The principle of this method of printing is quite different from all others. The depressed portions of the mould represent the different degrees of shadows, the level surface the high lights. When the pressure is applied, the flat portions squeeze out the fluid ink, leaving the surface of the paper white, while the hollows in the mould retain the pigment in quantity proportional to their depth.

Photo-Papyrography. This is an ingenious contrivance of Colonel Sir Henry James, the inventor of Photo-Zincography. In cases where the number of reproductions of maps, drawings, &c., is very small, it saves much time and labour if the negative be taken in a *reversed* position in the camera—that is, with the glass instead of the collodion nearest the lens; or a reversing mirror might be used for the same purpose. A print in greasy ink is then obtained as described under the article "Photo-Zincography." When dry it is laid, picture side downwards, on a piece of paper, and passed through a lithographic press. By such means, it is said, excellent impressions can be obtained.

We have not seen any specimens of these photo-papyrographs, but from Sir Henry James's description, the process seems to be a very promising one.

Photo-zincography. This process in principle is the same as photo-lithography, but some of the details are different. It was invented by Colonel Sir Henry James, and is now extensively employed in the Ordance Survey Department at Southampton for copying maps, &c.

A suitable paper is floated for two or three minutes on a warm solution about 100° of the following substances:—Bichromate of potash, 2½ ounces, dissolved in 10 ounces of hot water, to which are added 3 ounces of the purest gelatine previously dissolved in 40 ounces of hot water. The paper, after becoming dry, should be again floated on the same solution, and hung up to dry at the opposite corner to that by which it was first suspended, in order to distribute the sensitising solution uniformly. This must be done in the dark room. This paper will not keep long in a serviceable state even in the dark room, because the bichromate gradually oxidises gelatine without the action of light. Two days are about the limits of its keeping qualities.

The sensitive paper is exposed to the solar rays under a negative in the pressure-frame as usual. One minute in bright sunlight is often sufficient. The general indications, to judge of sufficient exposure, are the appearance of the parts where the light has acted most strongly. They should be of a deep tawny colour, tinged with green, and the shadows yellow.

Now comes that part of the process where the lithographer steps in to complete the work of the photographer. The print is removed from the pressure-frame, and *inked* by the following method:—

In an iron pot put 2 ounces of Burgundy pitch, 1 ounce of palm oil, and 1 ounce of bleached bees' wax; place the pot over a fire, and as soon as they begin to melt, keep stirring the mass till they are thoroughly incorporated, which will not take place till the ingredients have nearly reached the point of ignition. Then remove the pot from the fire, and intimately mix with the contents 1 pound of chalk lithographic ink, and half a pint of what is called in the trade *middle linseed oil varnish*, both of which must have been previously thoroughly incorporated by pounding in a mortar.

When required for use, a portion of the ink is melted with sufficient turpentine to make it of the consistence of honey. A little is then placed on a printing roller, and a flat zinc plate inked with it in the usual manner. The print is then laid face downwards on the zinc, and the whole passed through a press, by which means it receives an even coating.

The print is then removed from the zinc plate, and laid back downwards on water, at the temperature of about 100° Fahrenheit, for a few minutes. It is next placed on a level slab, and all the superfluous ink removed with a soft sponge dipped in gum water. It is afterwards treated with repeated baths of warm water till the ground is quite clear. When dry, it is ready for transferring to zinc or stone.

Mode of Transfer, &c. Colonel Sir Henry James's instructions on this part of the process are so very lucid and precise that we cannot do better than quote them:—

The Transference of the Print to Zinc, and Preparation for Printing.

When the zinc plates are received from the manufacturer, the surface has to be prepared to receive transfers. They are first planed with a razor blade, the back of which is set in a wooden handle; the ordinary edge is ground down flat, so that there are two edges to scrape with in turn, like the edges of a skate. The plate is thus cut down till all surface scratches, blisters, and other defects are obliterated. It is then ground down to a flat surface with pumice stone, and smoothed with snake stone, to take out any scratches made by the pumice stone. Finally, a grained structure is given to it by rubbing with fine sand and water, and a zinc muller. The muller is simply a disc of zinc, about half an inch thick and four inches in diameter, fixed to a wooden handle. It is grasped by the handle with the thumb uppermost, and rubbed over the surface of the plate with a circular movement.

The sand is brought to the requisite degree of fineness by sifting it through a wire sieve of from 80 to 120 holes to the square inch, according to the kind of grain required for the plate. The time required for two men to grain a zinc plate 3 feet long by 2 broad has been found to be about an hour. As soon as this process is completed, the plate is thoroughly washed with water and well dried. It should be kept from contact with any substance likely to communicate greasiness to it; and the sooner it is used for transferring the better, as the action of the atmosphere will tend to diminish the affinity of the surface for the greasy ink.

When it is desired to clean and prepare for receiving transfers a plate which has been used, the ink of the old transfer is cleared off with turpentine; the plate is then washed with strong alkali, and cleaned with water; an acid is then poured over it. This is prepared by taking equal parts of sulphuric and hydrochloric acid, and to 1 part of the mixture adding 12 parts of water. The acid is allowed to remain for two or three minutes on the plate; it is then washed off with plenty of water, and the plate is regrained in the manner already described.

The photographic print is laid between sheets of damp paper for a few minutes, placed face downwards on the zinc plate, with two or three sheets of paper over it, and passed through the press.

If the transfer print is not more than three or four days old, it will be sufficient to pass it through once; but an old print, on which the ink has had time to harden, will require to pass through the press two or three times.

The sheets of paper covering the transfer are then removed, and it is damped with a wet sponge for two or three minutes; this causes the gelatine in the lines to swell, and makes the ink leave them more readily.

The print is then pulled carefully off the plate, and nearly the whole of the ink should remain on the zinc.

The transfer is now etched; the etching liquid consists of a decoction of galls and a little phosphoric acid, mixed with a thick solution of gum and water.

It is prepared as follows:—

Four ounces of Aleppo galls are bruised and steeped in 3 quarts of cold water for twenty-four hours; the water and galls are then placed in a vessel over the fire, and allowed to boil up. This decoction is then strained. The gum water should be about the consistence of cream.

One quart of the decoction of galls is added to 3 quarts of the gum water, and to the mixture is added about 3 ounces of the solution of phosphoric acid, which is prepared by placing sticks of phosphorus in a pint bottle of water; this is stopped with a cork, in which is cut a small hole; the bottle is three quarters filled with water, and the ends of the sticks of phosphorus rise above the surface, and become oxidised by the air admitted into the bottle.

The phosphoric acid, as fast as it is formed, is dissolved by water. In a few days the solution is strong enough to use.

The etching liquid is poured on the plate, and wiped over the surface with a sponge or camel-hair brush; it is allowed to remain on for a short time, varying with the strength of the design: with fine work, twenty seconds would be sufficient; strong lines should bear the action a minute without injury. As soon as the solution has acted sufficiently, it is wiped with a soft cloth dipped in water—care being taken to remove all trace of it, if there are fine lines.

The transfer ink is next cleared from the zinc plate with turpentine, or, if the design is weak, with turpentine mixed with olive oil and gum water. It is then rolled up with printing ink, the roller being very thinly and evenly coated. Impressions can then be printed in the usual manner; 1500 is not an unusual number for the plate to stand without sensible deterioration.

The photographic print can be transferred to a lithographic stone in a similar manner.

When the subject admits of it, paper, enamelled with zinc white, should be used, as the impressions produced are most perfect.

It is prepared in the following manner:—

Four ounces of Russian glue are soaked in 3 quarts of water for some hours, and then heated till dissolved; 1½ pound of zinc white is ground with water on a slab, and then mixed gradually with the solution of glue and passed through a hair sieve.

A coating is brushed on the paper with a pound brush, and the streaks are obliterated by going lightly over the surface with a flat camel-hair brush. A second coating is applied in a similar manner, and hung up to dry: when dry it is ready for use.

For further particulars and details we refer the reader to Colonel Sir Henry James's work on "Photozincography."

Photometer, or Actinometer. An instrument for measuring the intensity of the actinic rays. Several methods have been devised for effecting this object, but they are all so liable to objections that it is hardly worth while describing any of them in this work.

Phototype. A secret process of printing in carbon, or pigments, invented by M. Joubert, of Porchester Terrace, Bayswater.

Pigments. Positive prints may now be obtained in various pigments by mixing them with an organic substance and bichromate of potash—applying the mixture evenly to the entire surface of a sheet of paper, drying it, and exposing it under a negative—then washing it in water, or a suitable solvent, which removes the pigment from those parts of the paper which have *not* been acted on by light, and leaves it firmly cemented to the paper in the parts which *have* been so acted on. The process of printing in pigments has not yet received much attention, and the results are at present more or less imperfect as compared with those by the old processes; but, since prints, by the methods in common use, are extremely liable, if not certain, to fade, it is of the utmost importance that the methods of printing in carbon and permanent pigments should not only yield proofs artistically equal to silver prints, which they already do, but to be carried out commercially on an economic scale.

The following is a brief account of some of the common pigments:—

Black. Ivory black is made by calcining ivory dust in a close crucible. Lamp black is the soot produced by the combustion of oils, resins, and other vegetable substances.

Umber. A brown mineral found in the island of Cyprus; it is composed of silica, alumina, and oxide of iron and manganese.

When calcined for half an hour at a red heat, the pigment called burnt umber is produced.

Asphaltum. A fine rich brown pigment. *See* "Asphaltum."

Sienna. An argillaceous mineral found in Italy, and also near Wycomb. By calcination it becomes burnt sienna.

Smalt blue. A glass coloured with oxide of cobalt, and pulverised.

Cobalt. Hydrate of alumina mixed with hydrated oxide of cobalt, dried and calcined.

Sulphate of indigo. Chemic blue, Saxony blue. Indigo dissolved in about six times its weight of sulphuric acid, then diluted with water, and neutralised with potash.

Prussian blue. A compound of cyanogen and iron. It is not considered a permanent pigment.

Stone blue. Finely-powdered indigo mixed with starch paste, and made into lumps.

Copper blue. A mixture of carbonate of copper and chalk, exposed to the air until it assumes the proper colour.

Ultramarine. A pigment composed chiefly of a costly mineral called *lapis lazuli,* brought from China and Persia.

Artificial ultramarine. A pigment containing sulphide of sodium, obtained by fusing together, in a crucible, porcelain clay, sulphur, and carbonate of soda. French photographic papers are tinted with this villanous alkaline sulphide, which is enough of itself to cause the fading of any photograph.

Blue verditer. Nitrate of copper mixed with chalk.

Copper green. Native sub-carbonate of copper.

Brunswick green. Carbonate of copper mixed with calcareous matters.

Vienna green. A mixture of arsenious acid and verdigris.

Green verditer. An accidental variety of blue verditer.

Sap green. The juice of the berries of buckthorn, black alder, or evergreen privet, mixed with lime water and gum arabic, and evaporated until quite thick.

Iris green. The juice of the petals of the iris added to quicklime.

Carmine. An extract from the cochineal insect.

Lake. The colouring matter of raw shellac.

Brazil-wood lake. A mixture of a decoction of logwood, alum, and chloride of tin, to which carbonate of soda is added to form a precipitate.

Madder. A colouring matter obtained from the root of the *Rubia torum,* which grows in the South of Europe.

Brown pink. To a decoction of French berries and fustic, boiled with potash in a *tinned* vessel, alum is added. The precipitate is "brown pink."

Dutch pink. Turmeric is substituted for fustic, and whiting for alum, in the preceding formula.

Orange red. Sandix. White lead calcined.

Red lead. Minium. Litharge (oxide of lead) roasted in a reverberatory furnace.

Indian red. Peroxide of iron.

Red chalk. Clay iron-ore.

Venetian red. Oxide of iron.

Alum white. A calcined mixture of honey and alum.

White lead. Basic carbonate of lead.

Permanent white. Carbonate of baryta.

Zinc white. Oxide of zinc.

Chrome yellow. Chromate of lead.

Indian yellow. A concretion formed in the intestines of the camel.

King's yellow. Sulphide of arsenic.

Naples yellow. A calcined mixture of lead, antimony, alum, and salt.

Patent yellow. Chloride of lead.

Queen's yellow. Turpith mineral, or sub-sulphate of mercury.

Yellow lake. French berries boiled with potash, and precipitated with alum.

Ochres. Native oxides of iron mixed with argillaceous and calcareous earths.

Verdigris. Acetate of copper.

Indigo. A product obtained from the indigo plant.

Sepia. The black liquid contained in the cuttle-fish. It consists of carbon, along with albumen, gelatine, and phosphate of lime.

Vermilion. Cinnabar. Protosulphide of mercury.

Terra verte. Silicate and phosphate of protoxide of iron.

Pins. Pins are used in Photography for hanging up papers by the corners to dry, or for pinning the corners to a board. Silver pins, or black coated with enamel, are the best.

Pipe Clay. A clay analogous to kaolin, and found in the Isle of Purbec and Dorsetshire. It contains a large proportion of alumina, and is sometimes used for decolorising old nitrate baths.

Plaster of Paris; Gypsum. This useful substance is made by roasting sulphate of lime at a temperature of about 500°, by which the water of crystallisation is expelled. When plaster of Paris is made into a paste with water, it soon solidifies, and this property

constitutes its value for taking casts or moulds. Stucco and scagliola are made by mixing plaster of Paris, coloured in various ways, with size and water, and polishing the surface. Gypsum, or native sulphate of lime, is frequently used as a manure, particularly for clover crops. Sulphate of lime is soluble in 500 parts of water, and it is this salt which principally renders water "hard."

Plate. In optics a transparent medium bounded by parallel plane surfaces is called a "Plate." When a ray of light is refracted through a plate, its direction at emergence is parallel to that at incidence, and it does not suffer deviation, but only displacement; the amount of displacement depending on the thickness of the plate. The same thing happens when a ray is refracted through any number of plates of different materials in contact; it merely suffers displacement and not deviation;—the medium external to the plates being supposed to be the same.

Plate Glass. This is made of the same materials as crown glass, and does not contain lead. Vast quantities of it are now used in Photography. Plate glass is made by pouring a quantity of the fused "metal" upon a table or cuvette of cast iron, and then passing a roller over the surface. The plate is then annealed, or allowed to cool slowly in an oven, or carquaise, along with others. When cold, the plate is removed, and carried in an upright position to a part of the manufactory where it is to be roughened down and polished. This is accomplished by fixing one side of the plate with plaster of Paris to a horizontal stone table, and another plate to a piece of apparatus above it. The apparatus is then put in motion, and the surface of the upper plate rubbed upon that of the under one, with wet sand between them, by a circum-rotatory motion, at the same time that a peculiar lateral motion is given to the table which supports the lower plate. When the plates are in this way sufficiently worked on one face, the process is repeated on the other. The plates are next smoothed in the same way by substituting moist emery for moist sand, and the polishing is effected by colcothar (oxide of iron) applied by rubbers of felt. The final polishing is given by women, who rub two plates together with a little moistened putty of tin between them.

Manufacturers of plate glass should be particular not to pack it en intended for Photography, with printed papers between ts; for it has been found that permanent impressions are thus icated to the glass, which are reproduced upon the photo- It has been affirmed that these impressions sometimes oe removed by the strongest nitric acid.

Plate Paper. The thick bibulous paper upon which engravings are printed.

Platinum, Bichloride of. Pt $Cl_2 = 169{\cdot}6$. This, the perchloride of platinum is formed by dissolving the metal in nitro-hydrochloric acid, and evaporating to dryness. The dark brown residue forms a deep yellow solution in water, which, when quite neutral, and added to lime water, gives a copious white precipitate in the sun's rays. It has been proposed to determine by the weight of this the actinic power of the light at the time. The aqueous solution has been tried as an etching liquid in engraving photographs on steel plates; and as a toning agent for paper positives instead of chloride of gold.

Plumbago, Black Lead, Graphite. This substance is composed of carbon and iron, and contains about 8 per cent. of iron. The finer kind is used for black-lead pencils, and the coarser kinds for polishing grates, diminishing friction in machinery, &c. It is almost exclusively obtained in a pure form from the mine of Borrowdale, in Cumberland; it is infusible, very difficult of combustion, and sometimes occurs crystallised in hexangular plates. In an impure form it is not an uncommon mineral, and is found in detached masses, generally among primitive rocks.

Plumber's Solder. Equal parts of lead and tin.

Polarised Light. *See* "Light."

Portrait Room. *See* "Glass House."

Positives. This is the name given to photographs which have the lights and shades rendered as they are seen in nature; and it is used to distinguish such pictures from *negatives*, which have the lights reversed.

Potash. KO, HO = 56. "Caustic potash," or hydrate of potash, is obtained by boiling together in an iron vessel slaked lime and a solution of carbonate of potash. The carbonic acid leaves the potash and goes to the lime, forming an insoluble precipitate of carbonate of lime, and the potash remains in solution. When a little of the liquid taken out ceases to effervesce on the addition of an acid, the decomposition is complete. The clear liquid is then drawn off into an *iron* or *silver* vessel, evaporated to dryness, fused in its own basic water, and run into moulds. The sticks thus formed still contain a little carbonate; this is removed by dissolving them in absolute alcohol, when the carbonate of potash is precipitated as insoluble, but the plan is open to objection since the alcohol is liable to be decomposed.

Caustic potash is soluble in half its weight of cold water. It is highly alkaline and caustic, acting energetically upon most organic substances, and dissolving sulphur, alumina, silica, and several sulphides; its aqueous solution, also, dissolves the oxides of some of the metals, as manganese, zinc, lead, tin, antimony, cobalt, nickel, &c., and acts upon glass, particularly when at a boiling heat. It is freely soluble in alcohol, and fuses at a red heat.

Potash, Bichromate of. $KO, 2 CrO_3=147{\cdot}5$. This salt is obtained by acting on the chromate of potash with nitric or other acid. The acid abstracts half the potash, and deep orange or red crystals are deposited, which are the bichromate.

Bichromate of potash, in contact with gelatine or other organic matter, is decomposed by light, and gives up half of its oxygen to the organic body, which, if previously soluble in water, is now in some instances—gelatine, for example—rendered insoluble. This important property of bichromate of potash is the foundation of several photographic processes, and the chemical action is strictly analogous to that of the use of nitrate of silver alone on paper. A visible image is impressed on the paper, on which reduced silver and other metals (iron, &c.) may be afterwards precipitated by suitable developing solutions. When protosulphate of iron and gallic acid are employed, the picture, or its chemical composition, resembles writing ink. The iron and other metallic solutions are sometimes presented, with the bichromate in the paper, to the action of light, and the variety of modifications appears to be infinite. The insoluble compounds of chromium, formed by light, and the action of the light itself, have both been used in the art of dyeing, the chromium forming a mordant on the textile fabric, in parts exposed to light through a perforated pattern, on which mordant the colours are subsequently applied; or the colours may be put on with the bichromate, and subsequently washed out from the parts not acted on by the light, just as in a similar photographic process on paper. Papers prepared with bichromate of potash and nitrate of silver have also been found to give images varying in colour from red to green, and blue.

Potash, Carbonate of. $KO, CO_2=69$. The *pearl-ash* of commerce contains a variety of impurities, such as chloride of potassium and sulphate of potash, and is obtained by the combustion of vegetables and lixiviating the ashes. The solution thus obtained is drawn off, evaporated to dryness, and then calcined to destroy the organic matter which it contains.

A pure salt is obtained by exposing pure cream of tartar to a red heat and separating the carbonate by means of distilled water.

Carbonate of potash is extremely deliquescent and soluble in less than its own weight of water. It is quite insoluble in alcohol. For this reason it is sometimes shaken up with weak alcohol to deprive it of its water. None but the pure salt should be used for this purpose.

Potassium. K=40. This singular metal is obtained by expelling the oxygen from potash, either by exposing it to intense heat in contact with charcoal, or by voltaic electricity. It is a bluish white metal of great lustre, which fuses at 150°, boils at a red heat, floats upon water, and takes fire by coming into contact with water in consequence of its great affinity for oxygen. It must be preserved under naphtha.

Potassium, Bromide of. K Br=119. When bromine is added to a solution of caustic potash, bromide of potassium and bromate of potash are formed. The mixture is evaporated and heated to redness, by which means the oxygen is expelled from the bromate, and bromide only remains. It crystallises in cubes, which are very soluble in water, but only soluble in alcohol according to the proportion of water which it may contain. In this respect it exactly resembles the iodide of the same metal.

Bromide of potassium was extensively used in the paper—especially the waxed-paper—negative processes. It is also occasionally used in collodion, but is rapidly being displaced by other bromides more soluble in strong ethereo-alcoholic solvents of pyroxyline.

Potassium, Chloride of. K Cl.=74·5. This dissolves in 3 parts of water at 60°, but is insoluble in alcohol. This salt is a residue in several chemical processes, and is often present as an impurity in the iodides and bromides of the metals, and in nitre as occurring in commerce. In preparing papers it is not much used, though the nitrate of potash formed in sensitising would not be so likely to damp the paper and spoil it when kept, as nitrate of soda.

Potassium, Cyanide of. K, C_2 N, or K Cy.=65. The principal employment of this salt in Photography is in forming a small proportion of cyanide of silver with the iodide, and in fixing. The former of these uses is not to be commended. As met with in commerce, it often contains a large proportion of carbonate of potash, which is detected by the effervescence produced when an acid is added to its solution: from the usual mode of its preparation, it often also contains cyanate of potash, but not in very large quantity, and this is not injurious. It is deliquescent, and especially

so when contaminated with carbonate, but it is not soluble in cold alcohol. By dissolving it in boiling alcohol the impurities are removed, and on cooling, pure cyanide of potassium is deposited. When dissolved in water it may be crystallised in cubes. It is as poisonous as prussic acid (hydrocyanic acid) itself: the best antidote, and one very convenient to the photographer, is protosulphate of iron. It is used from 2 to 20 grains to the ounce of water in fixing photographs, according to the purity of the article. Its properties for this purpose differ from those of hyposulphite of soda, and it is more energetic. Like "*hypo*," it forms double salts with the chloride and other compounds of silver, which salts contain one equivalent of cyanide of silver and one of cyanide of potassium: they are not decomposed by water, as the double salts produced by other fixing agents are, so that no apprehension need be entertained of precipitating cyanide of silver in the washing: and it dissolves much more silver on this account than weak "hypo" will do. It also acts more quickly; being weak, it is soon saturated, and is more quickly and completely removed by washing, so that comparatively very little washing is required. It is never found to crystallise in the film, and but very few instances have occurred in which the washing has been so careless as to leave enough in the film to react on the picture. Cyanide of potassium has also an affinity for oxygen, and has therefore considerable reducing powers, so that the oxides of copper and other metals thrown into it in the fused state are presently brought to the state of pure metal, and the cyanide becomes cyanate. This reducing power is also seen in fixing collodion pictures, which have a more metallic lustre when fixed with it than when the "hypo" salt is used. All these are important advantages, but it is not adapted for fixing pictures on albumen and paper, from the power it has of dissolving the organic basis, and reduced silver in combination with it, as well as the unaltered chlorides and other salts.

From its highly poisonous properties, this otherwise very useful salt has been banished from many photographic laboratories. Some persons are so susceptible to its influence, that, by absorbing it through the skin, or a cut in the hand, while fixing a plate, serious inconvenience has been experienced. It should also be borne in mind by the operator who uses it for fixing a negative that an acid decomposes it, and causes it to give off fumes of that highly poisonous substance, hydrocyanic or prussic acid, the first symptoms of which are a sense of constriction of the throat and giddiness. It must, therefore, be used, under all circumstances, with the utmost caution.

Potassium, Fluoride of. $KF=58$. Fluoride of potassium was at one time used in Photography in the iodising solutions for waxed papers. It is doubtful whether any advantage was thereby gained, for, although fluoride of silver is sensitive to light, and will yield a developable image, it is apparently much less sensitive than the iodide and bromide.

It may be prepared by saturating hydrofluoric acid with potash, and evaporating to dryness in a platinum vessel, not in a glass one, because it acts on it like hydrofluoric acid.

Potassium, Ferro-cyanide of, or Yellow Prussiate of Potash: $K_2\,Cfy + 3HO$, or $K_2\,C_6\,N_3\,Fe + 3HO = 211{\cdot}4$. This salt is soluble in 4 parts of cold and 2 parts of hot water; it is insoluble in alcohol, which throws it down in yellow flakes from its aqueous solution. The crystals are four-sided tables derived from a primary octahedron. The salt is not poisonous. When in crystals, the oxygen and hydrogen of the water of crystallisation are exactly in such proportions as are required to convert the metals into protoxides and the cyanogen into hydrocyanic acid (prussic acid).

Ferro-cyanide of potassium is prepared as an article of commerce by putting chips of hoofs, animal horns, woollen rags, greaves, &c., into an *iron* pot, and burning them at a very high heat with potash, so as to form what is called "prussiate cake." This, when cold, is lixiviated with water, and evaporated. The resulting crystals are an impure ferro-cyanide of potassium. These are purified by being redissolved and recrystallised. The vessels and stirrers used in the operation should be of iron, as they then supply the iron contained in the salt. If not in sufficient quantity, iron filings should be added.

Potassium, Iodide of. $KI=166$. Iodine and potassium unite energetically, giving out heat and light; and potassium burns in the vapour of iodine. The result of this combination is the white anhydrous salt—iodide of potassium. The mode of producing this salt commercially is to add iodine to a solution of potash, until it assumes a brown colour; then evaporate to dryness, add a little charcoal, and fuse the residue at a red heat, which decomposes any iodate of potash that may be formed; dissolve, filter, and recrystallise the salt.

Sometimes iodide of potassium is made by passing sulphuretted hydrogen through a brown mixture of liquor potassæ and iodine, till it becomes colourless; expelling any excess of sulphuretted hydrogen by heat, filtering, neutralising with potash, and crystallis-

ing. Another way is, to decompose either iodide of zinc or iodide of iron by carbonate of potash.

Iodide of potassium crystallises both in cubes and prisms. The crystals are anhydrous, and very slightly deliquescent in damp air. They are extremely soluble in water, 100 parts of which dissolve at 65° 143 parts of the salt, with production of cold. It is soluble in alcohol only in proportion to the quantity of water which the alcohol may contain.

The impurities contained in commercial iodide of potassium are iodide, carbonate, and sulphate of potash, chloride of potassium, and sometimes of zinc and iron.

Carbonate and sulphate of potash are detected by adding chloride of barium to the solution, which throws down white insoluble carbonate, or sulphate of baryta. Another test for carbonate of potash is to expose the alcoholic solution of the iodide to sunshine; if it soon becomes slightly discoloured, it is pure, if not, it contains carbonate. The presence of much carbonate of potash renders iodide of potassium highly deliquescent.

Aqueous solution of iodide of potassium is immediately discoloured by the addition of chlorine water, or nitric acid, but not by the weaker acids, in the dark; in the light the discoloration proceeds more rapidly.

This salt is much used, and is the best for iodising papers for the calotype and waxed-paper processes. It is not, however, the best for collodion, unless the purest materials are employed to dissolve the pyroxyline, and the developer be pyrogallic acid; its proneness to decompose when acid or active oxygen—ozone—is present in the collodion renders it inferior to other iodides, which are not so liable to decomposition, and possess qualities of another kind equally good, if not superior, to itself. Besides, when highly rectified, ether and alcohol are used to dissolve the pyroxyline, as they should always be: a sufficiency of a potassium iodiser cannot be dissolved in the collodion.

Potassium, Sulphide of. *See* "Liver of Sulphur."

Potassium, Sulpho-cyanide of. K, S_2 Cy=97. If 184 parts of dry ferro-cyanide of potassium, 128 of sulphur, and 69 of dry carbonate of potash are pounded up together, thoroughly mixed, and fused for a considerable time in a covered iron crucible, sulpho-cyanide of potassium and sulphuret of iron are formed. The fused mass, when it has become quite cold, must be stirred up with water and filtered, then the solution on evaporation will yield prismatic crystals of this salt, pure enough for photographic purposes.

The sulpho-cyanides of ammonium and potassium have been recommended for fixing photographic positive prints, in lieu of hyposulphite of soda, which is so prone to form deleterious compounds, which act on the images and promote fading. It is very doubtful whether the sulpho-cyanides are less hurtful. This remains to be proved.

Precipitate. Any substance which separates in a solid or pulverulent form from a solution. The substance which produces the precipitate is called the *precipitant,* and the act by which it is produced is called *precipitation.*

Preservative. In Dry-Plate Photography it is customary to apply to the sensitive film some organic substance, in order to give density and transparency to the negative, and to cause the film to adhere.

It is found that unless organic matter of some kind be introduced in this way the negative is thin and veiled. Albumen and tannin are the best preservatives at present known, the former being used in the Taupenôt and Fothergill, and the latter in the Tannin processes. The term "preservative" is a misnomer, and has arisen from a mistaken notion of the real use of the application of organic matter. Its real office will be easily understood by comparing two pictures treated in every way alike, except, that one has, and the other has not, a preservative applied to it.

Print Varnish. A compound of benzole and almond oil. When applied to a dead-looking silver print upon plain paper, it gives it freshness and vigour, and at the same time imparts to the paper the agreeable colour of India paper. If the print has not been properly fixed, the application of the varnish renders this fault instantly apparent, by showing the sulphide that exists within the pores of the paper. Print varnish does not give the slightest glaze to the picture. It should always be used with sun-prints upon plain paper; but not with developed prints.

Printing Ink. This may be applied as a backing to collodion positives. It does not crack. To apply it, first rub the back of the plate over with it, then smear a piece of paper with it, press the two blackened surfaces together, and put the plate at once into the *passe-partout.* It may also be used for blackening the skies of collodion negatives.

Printers' ink is made by grinding lamp black in printers' varnish, which is a mixture of linseed oil, resin, and yellow soap. By adding more varnish it may be thinned to any extent.

Printing-Ink Process—Pouncy's. The nature of this new and very remarkable process will be best understood from the specification of it by the patentee. It is as follows, and bears date July 28th, 1863:—

"My said invention relates to certain improvements in obtaining, transferring, and printing from photographic and any other pictures or images, and also in preparing the materials for such processes, the main or principal feature of my invention consisting in the employment of a sensitive or sensitised ink, or composition, on which pictures or images may be produced by the agency of light, and which may be transferred or printed from in the manner hereinafter mentioned. The surfaces employed for the reception of the pictures or images may be paper, silk, linen, cotton or mixed fabrics, leather, wood, ivory, glass, porcelain, or stone, or surfaces of metal, or of metallic alloys, may be used, or any other surface. The surface proposed to be employed is coated with an ink, or composition, consisting of carbonaceous or other colouring matter (according to the colour or tint of the picture desired to be produced), fat, tallow or oil, bichromate of potash, or bitumen of Judæa, or both of such last-mentioned substances, and benzole, turpentine, or other hydrocarbon or analogous spirit. The respective proportions of the several ingredients hereinbefore mentioned will vary with the circumstances attending the operation. The mode of compounding such ingredients and the necessary proportions thereof, will be well understood, by persons conversant with the preparation of similar or analogous inks or compositions, with the addition of the two last-mentioned substances, dissolved in either of the spirits before named. I may mention, however, that if the photographic picture or image is to be transferred on to stone, or any other surface suitable for being printed from, a larger quantity of oil or fatty matter is employed in preparing the ink, or sensitive composition, than when the picture or image is simply taken on paper or any other surface, and is to be used merely in that form. The ink or composition must be prepared and applied to the surface of the material employed in the dark, or in a place from which the actinic rays of light have been excluded, or by an artificial light, which does not act photographically. The coated surface is to be dried and excluded from the light until it is about to be used, when a photographic picture or image may be produced thereon, by any of the usual and well-known methods applicable to the purpose. When the picture or image is to be produced by means of a negative picture or image applied to the sensitised surface, prepared as aforesaid, and the substance or material is sufficiently transparent to allow the

rays of light to act through the same, the negative picture or image may be placed on the uncoated surface, and the light applied so as to act on the coating through the transparent substance or material.

"The rays of light having hardened the parts required, and produced the desired effect on the sensitised coating, the parts not acted on thereby, remaining soluble, are then washed off with benzole, turpentine, naphtha, or other hydrocarbon solvent. The picture or image will thus be left upon the surface employed, in printing ink, or in a composition in the nature of or analogous to printing ink, and from which impressions can be obtained, as hereinafter mentioned.

"The pictures or images, obtained in the manner hereinbefore mentioned, are applicable to a great variety of purposes, both useful and ornamental. They may be preserved simply as works of art, or they may be transferred (if a suitable material for receiving the sensitive coating has been employed) to the surface of porcelain or other ceramic manufactures, and 'burnt in' or permanently imparted thereto, according to the well-known methods of performing such operations.

"When the sensitive ink or composition is applied to a lithographic stone, for the purpose of printing therefrom, the surface of the stone must be 'grained' before the application of the ink or composition, and the surface of the coating should be also grained, after it has been laid on the surface of the stone. The process of graining is well understood, and therefore I need not describe the same. Before transferring the picture to the stone, the surface thereof should be moistened with water, and it should be used in the press in a cold state, and not heated, as is frequently the case in ordinary lithographic printing."

Further particulars will be found in a shilling pamphlet, by Mr. Sutton, entitled "Photography in Printing Ink," and published by Messrs. Sampson Low, Son, and Marston, Ludgate Hill.

Printing Process. By "printing" is meant the reproducing a positive, in which the lights and shades are true to nature, from a negative in which they are reversed. The operation, not being attended with the destruction of or injury to the negative, may be repeated indefinitely, and therefore any number of prints may be taken from the same negative.

There are two methods of printing; one consists in copying the negative by means of a lens, the other by pressing it upon a sensitive tablet in a pressure frame, and exposing it to direct light. In both cases the light which produces the print is transmitted through

the transparent parts of the negative, and stopped by its opaque parts. The particulars of the former method are described in the article on "Copying" (*q.v.*) It only remains, therefore, to describe the latter mode of proceeding: viz., printing by superposition.

There are two methods of printing by superposition of the negative upon a sheet of sensitive paper. One is called Sun-printing, the other Development-printing.

In sun-printing the paper is said to be either "plain" or "albumenised."

The process of sun-printing upon plain paper is as follows:—

Use the best Papier Saxe, or Rive, both of which are manufactured on the Continent, and have a finer surface than English papers.

Float the face of the paper for a minute upon a bath composed of—

Filtered rain water	1 oz.
Gelatine	3 grains.
Chloride of sodium	6 grains.

The ingredients are to be boiled together, strained, and used when cold. Hang the papers up to dry by a pin at one corner.

Excite the paper by brushing it over with, or floating it for a minute or two, on the following solution of ammonio-nitrate of silver:—

Distilled water	1 oz.
Nitrate of silver	50 grains.

When dissolved, add ammonia, a drop or two at a time, until the brown turbidity at first formed is exactly redissolved, and the solution becomes again clear.

Hang up to dry in a warm dark room.

The papers should, if possible, be used the same day on which they were excited, because they spontaneously turn brown by keeping.

Expose under the negative in the pressure frame until the picture is somewhat over-printed, and then proceed to tone, fix, &c., as described below for albumenised paper.

To Print on Albumenised Paper. For the method of preparing this paper, *see* "Albumenised Paper." To sensitise it, make a solution in the following proportions:—

Nitrate of silver.	80 grains.
Distilled water	1 ounce.

This strength of solution is suited for paper coated with albumen containing from ten to fifteen grains of salt. If less than ten grains of salt be used, then fifty or sixty grains of nitrate of silver to the ounce of water is quite sufficient to fully sensitise it. The strength

of the nitrate bath should always be regulated by the amount of salt in the paper. The thickness of the paper also exercises considerable influence. The thicker it is the stronger should the solution be. The above proportions are well suited for *thick* papers. They may be diminished when using *thin* papers.

Pour a sufficiency of the solution into a flat-bottomed porcelain or glass tray, to cover the bottom to at least the depth of one-eighth of an inch. Lay down on the surface of the liquid, the albumenised side of the paper carefully, so as to avoid air bubbles. A very little practice makes this operation easy. Let the paper lie on the sensitising fluid for two or three minutes, then hang up by the corner to dry in the dark room. Like the sensitised plain paper, it will not keep long without turning brown. It should therefore be used as soon after it becomes dry, as convenient.

Expose in the pressure frame as before, until the picture is somewhat overprinted.

Toning Operation. When the proofs have been removed from the pressure frame, keep them in a dark cupboard till the printing for the day is over; then wash them thoroughly in several changes of common water, to remove all the free nitrate of silver, which would otherwise interfere with the subsequent operations. The first washing water should be preserved in a large stock jar, and the nitrate precipitated with chloride of sodium. In this way more than half the silver used can be recovered. *See* "Wastes."

The prints are now ready for the gold toning bath, for which many formulæ have been recommended. The two most generally adopted are as under:—

(1.) Chloride of gold . . . . 1 grain.
Water . . . . . . 10 ounces,

and carbonate of soda just enough to neutralise the acidity of the gold or make it very slightly alkaline.

(2.) Chloride of gold . . . 1 grain.
Water . . . . . . 10 ounces.
Acetate of Soda . . . 50 grains

Bath No. 1 will be in good working order after being mixed one hour. Bath No. 2, should be mixed at least twelve hours before use, otherwise the prints will be mealy and altogether unsatisfactorily toned. There is little difference in the tone produced by both, but the acetate of soda bath may be used over and over again for many days by simply replenishing it with gold as it gets exhausted. The carbonate bath soon becomes unserviceable and deposits the gold which it has in solution. The above proportions of gold ought fully to tone one whole sheet of prints (22 × 18 inches). When

more proofs are placed in the bath the quantity of gold must be increased proportionally.

The prints should be taken from the washing water and at once immersed one by one into the toning bath. It is necessary to move them about without intermission, otherwise they will certainly be unevenly toned. Of course those first immersed will have assumed the requisite depth of colour before the others. For this reason it is advisable to have a large dish of plain water near at hand to throw the prints into as they get toned. It will not do to throw them into the fixing bath at once, unless an assistant is ready to thrust them at once under the fixing solution, for if a single drop of hyposulphite is allowed to enter the toning bath, both it and probably many of the prints will be irretrievably injured.

The fixing solution :—

Hyposulphite of soda . . .	6 ounces.
Water	1 pint.

The object of this bath is to dissolve out all the chloride and other salts of silver which have not been reduced by light. The picture could have no permanence unless they were removed. An immersion in a bath of the above strength, for from ten to twenty minutes, fixes the prints. The bath should not be used oftener than two or three times, nor should many prints be immersed in it at the same time.

After fixing, the prints have again to be washed in abundance of water, so thoroughly, that no traces of hyposulphite shall be left adhering to them. It takes several hours and many changes of water to effect this completely. When washed, they may be spread out to dry on sheets of clean blotting paper, or suspended by clips.

Printing by Development. Use Hollingworth's *thin* photographic paper; (the thick sort is useless.) Immerse it in the following bath :—

Filtered rain water . .	1 ounce
Salt	6 grains
Lemon juice . . .	1 drop.

The time of immersion may lie between one minute and 24 hours without producing any marked difference in the result.

Excite the paper by floating it upon a nitrate bath made thus :—

Distilled water . . .	1 ounce
Nitrate of silver . . .	30 grains
Lemon juice . . .	6 or 8 drops.

Hang it up to dry, and use it as soon as possible.

Expose it in the pressure frame until a faint trace of the picture is visible.

Develop it thus :—

Turn up the edges of the paper all round so as to make it into a tray. Lay it, with a sheet of blotting paper underneath, upon a horizontal sheet of glass, and pour upon the darkest part of the picture a little saturated solution of gallic acid, which spread with a bent glass rod. The development immediately commences, and is completed in a few minutes. Do not stop it at too early a stage, before the blacks have acquired the proper intensity.

When the picture has been well washed, to remove the gallic acid and excess of nitrate of silver, it may be toned in alkaline gold if deemed desirable; but this is seldom necessary, because the blacks are generally very fine without this complication. Of course the pictures must be fixed in hyposulphite of soda, and thoroughly washed.

Many modifications of the printing of positives by development will suggest themselves, by means of different haloid salts of silver, but the above is perhaps as good as any.

Prints, Colouring. Before colouring an engraving or photograph upon bibulous paper it must be sized, by applying to it the following mixture :—

Dissolve four ounces of glue and four ounces of white soap in three pints of hot water; add two ounces of powdered alum; stir well together, and it is ready for use. It is to be applied cold, either with a sponge or flat camel-hair brush.

Prism. In solid geometry a prism is a solid described by the motion of a straight line which in passing round the boundary of a plane rectilineal figure always preserves its parallelism, the solid being terminated at the other extremity by a plain figure parallel to the first. In optics, however, the term prism is confined to the case of a prism with a triangular base, and its sides rectangles perpendicular to the base.

In optical experiments with the prism, the edge of the prism is in general very sharp, the two adjacent planes which form it being inclined at a very small angle, called the "refracting angle of the prism." When the prism is so placed with respect to a ray of light refracted through it as that the emergent and incident rays make equal angles with the sides of the prism, the deviation of the refracted ray is a minimum.

Suppose a prism to be placed in its position of minimum deviation with respect to a ray refracted through it near its edge, and let D be the deviation of the refracted ray, μ the index of refraction of the material of which the prism is made, and a the refracting angle

of the prism; then, *if the angle made by the incident ray be small*, $D = (\mu - 1)\,a$.

A ray of light refracted through a prism is decomposed into rays of different refrangibility and colour, because the deviation of a ray depends upon the refractive index of the prism for that ray, and since white light is not homogeneous but composed of light of different degrees of refrangibility, the refractive index will vary with the different rays of which white light is composed, being greatest for the violet and least for the red rays, therefore the deviation will be different for rays of different colours.

If a second prism, precisely similar to the first, be placed against it in such a way as that its edge is next to the base of the first prism, the two prisms will form a plate, and a ray refracted through them will neither suffer deviation nor decomposition; that is to say, the effects produced upon it by refraction through the first prism will be exactly counteracted by refraction through the second, so that the second prism will re-compose into white light the rays which were dispersed by the first. The second prism therefore achromatises the first; *but the refracted ray does not suffer deviation*, there is, therefore, no optical utility in such an arrangement. But if the second prism be made of a different material from the first, having different refractive and dispersive powers, and a suitable refracting angle be given to it, the first prism will be achromatised by the second, *and the ray will suffer deviation.* This important result depends on the fact that the dispersive power of a medium is not proportional to the deviation produced by it.

This being the case, opticians are fortunately able to achromatise lenses and prisms. To be very exact, however, it must be remembered that in consequence of the irrationality of dispersion two prisms in contact can only unite two of the coloured rays or lines of the spectrum.

Proof Spirit. Alcohol, sp. gr. ·92 at 62° Fahrenheit. *See* "Alcohol."

Prussian Blue. A peculiar compound of cyanogen and iron, the exact formula of which has not been determined, but may be represented approximately by $6\ KO + 4\ Fe._4\ Cfy._3$.

This substance is much used both as a dye and pigment. It is made by precipitating solutions of peroxide of iron with ferro-cyanide of potassium (yellow prussiate of potash.) It is insipid, inodorous, insoluble both in water and alcohol, and not poisonous. The alkalies decompose it, and it does not therefore, as a dye, resist the action of soap. According to Chevreul, it becomes white by exposure to

sunshine, but recovers its colour in the dark. It has a strong attraction for water.

Pumice Stone. A grey porous stone found in the neighbourhood of active and extinct volcanoes, and supposed to have been thrown up by them. It is used by painters for smoothing surfaces intended to be painted; and, when pounded, by other artificers for polishing glass, metals, &c. To photographers it is useful in assisting to remove silver stains from the hands.

Purple of Cassius. This is a fine purple pigment used in enamel painting, and staining glass of a red colour. It is composed of the mixed oxides of gold and tin, and is precipitated by immersing a piece of tinfoil in a solution of chloride of gold. Its composition is $Au. O + 3 Sn. O_2 + 4 HO$.

Putty Powder. Polisher's Putty. Peroxide of tin.

Pyro-Gallic Acid. $C_{12}H_6O_6 = 126$. This substance is extensively used by photographers as a developer in the negative collodion process.

It may be made by exposing gallic acid to a temperature of about 420°, when it sublimes, and may be collected in the form of white shining scales; but is apt to be contaminated with empyreumatic oils.

A better plan is to treat finely-powdered galls with successive portions of cold water until exhausted, then to collect all the infusions and evaporate them to dryness. The spongy deliquescent mass thus produced must then be pounded and spread upon the bottom of an iron vessel 3 or 4 inches deep and 1 foot in diameter, the top of it being covered with a piece of blotting-paper pierced with pin holes, and surmounted by a paper cap 12 or 18 inches high. The pan is then cautiously and uniformly heated for some hours at a temperature of 400°, but not over 450°. The crystals of pyrogallic acid collect in the cap, and the other products are absorbed by the blotting-paper.

Pyrogallic acid is not a *real* acid, and does not redden litmus paper. It is white, crystalline, inodorous, and bitter; and very soluble in water, alcohol, and ether. The aqueous solution blackens by long exposure to air, and deposits a brown powder. It gives a deep *indigo* colour to a solution of *proto*sulphate of iron, if *pure* and free from *per*sulphate, to which it gives an *orange* colour.

Pyrogallic acid is blackened by chlorine, but iodine has no effect upon it.

It is a powerful deoxidiser, and reduces the oxides of the noble

metals; hence its use as a developer in Photography. It combines with oxide of lead, and forms a white powder.

Pyro-Ligneous Acid. A crude vinegar obtained by the destructive distillation of wood. When purified, it is used as a substitute for vinegar in many processes of the arts, and also in making pickles, sauces, &c.

Pyro-Ligneous Spirit. Pyroxylic Spirit. *See* "Wood-Alcohol."

Pyroxyline. General formula $C_{36}\ H(_{30})-x\ (NO_4)x\ O_{30}$. This name is applied to a remarkable series of compounds obtained by acting on vegetable fibres with nitric and sulphuric acids. They are all of that class denominated in chemistry "substitution compounds," that is, they are vegetable fibre in which hyponitric acid or peroxide of nitrogen (NO_4) is substituted for an equal number of atoms of hydrogen which the fibre may contain. They are all explosive in a greater or less degree.

The late Mr. Hadow, of King's College, has analysed and described several varieties made in cold acids, which he thus tabulates:—

A.	$C_{36}\ H_{21}\ (NO_4)_9\ O_{30}$
B.	$C_{36}\ H_{22}\ (NO_4)_8\ O_{30}$
C.	$C_{36}\ H_{23}\ (NO_4)_7\ O_{30}$
D.	$C_{36}\ H_{24}\ (NO_4)_6\ O_{30}$

A is highly explosive and insoluble in ether and alcohol; the other varieties as they descend in the scale are less explosive but more soluble to C in ether and alcohol.

But pyroxyline for photographic purposes must not be made in *cold* acids, because such pyroxyline forms a collodion viscid and clotty, refusing to flow over the plate evenly, and being otherwise deficient in good photographic properties.

Innumerable formulæ have been published for the preparation of pyroxyline suited for Photography, some of which are good and others utterly unreliable for any purpose. The three following formulæ are condensed from articles in the "British Journal of Photography," written by one of the editors of this dictionary, who has had extensive experience in the manufacture of this compound.

1st Formula.

NITRATE OF POTASH AND SULPHURIC ACID.

Pulverised and dried nitrate of potash .	8 ounces	by weight.
Sulphuric acid, sp. gr. 1840 . . .	14 „	by measure.
Water	1 „	„
Best dried cotton wool . . .	165 grains.	

The nitrate of potash should first be reduced to a fine powder in mortar, thoroughly dried in an oven or near the fire, and then weighed.

The sulphuric acid of commerce (unless purposely diluted) varies in strength from 1836 to 1845. We have taken 1840 as a standard on which to found the proportions of the above formula. Should the specific gravity be as low as 1836, the only change in the above proportions which will be necessary is the omission of the water altogether, and should it be as high as 1845 the water must then be increased to two ounces.

The cotton may be of that kind known at the chemist's as medicated cotton wool of long fibre: the short fibred varieties are useless. It must be well dried by artificial heat before use, on account of its strong hygroscopic properties.

The vessel in which the pyroxyline is to be made should be one composed of some thick non-conducting material. A Wedgwood mortar answers well, but if that be not conveniently at hand, one of the common red earthenware glazed pipkins will be found an efficient substitute.

Provide also beforehand two strong glass rods, or, better still, two sharp-pointed pieces of dry wood, for the purpose of pressing down the cotton in the solution, and keeping it from *matting* and being unequally acted on after immersion.

When all these materials have been got together and placed in a convenient place for commencing operations, the pipkin or mortar is to be warmed. This is best effected by pouring into it hot water, and allowing it to remain there till the outside feels warm to the touch. Empty out the water; quickly wipe the inside dry with a cloth, and place the vessel on the "hob," or under a flue, which will carry off the pungent and hurtful fumes formed during the operation. Without loss of time put in first the powdered nitrate of potash, then the water, and stir for three or four seconds with one of the glass rods, or pointed sticks. Add the sulphuric acid, and stir for three minutes, as before, until the mixture is complete. When the three minutes have expired, an assistant should be at hand with the cotton, which he is to throw into the vessel in small, well-pulled-out tufts, one at a time, while the principal operator pushes them under with the rods, and keeps moving them about. The time occupied in immersing the cotton ought not to extend over two minutes. When all is immersed it should be teased and pulled about under the acid for five minutes, at the end of which time the process may be considered complete. A longer soaking is often recommended, but there is no necessity for it, and by so doing a

risk is run of allowing the temperature to fall too low, and thereby injuring the quality of the pyroxyline.

The moment "time" has been called by the assistant, dash the contents of the pipkin into a large tub of water, and with the rod or with the hands—if they are not too delicate for such work—instantly pull out the cotton, and move it backwards and forwards under the water. This is important, for were it not at once intimately mixed with a large body of water, part of the cotton would be dissolved by the sudden rise of temperature consequent on a partial dilution of the acids in immediate contact with the fibre.

The washing is best effected by soaking the pyroxyline in many changes of water, and squeezing it as dry as possible in the hand between each change. But greater care than ordinary is needed in the washing of cotton prepared from nitrate of potash and sulphuric acid; for a secondary compound, generally supposed to be bisulphate of potash, is formed in the course of the operation, adhering, with almost obstinate tenacity, to the fibre of the pyroxyline, and it is with difficulty removed. As bisulphate of potash is very soluble in water, we are inclined to attribute to this adhering salt a more complex composition than that usually given to it. At all events, it is effectually got rid of by steeping, for half an hour, the well-washed pyroxyline in a little distilled water, to which a few drops of ammonia have been added. The ammonia is easily removed by three or four subsequent washings, and its application seems to have no injurious action whatever on the cotton.

Pick out and dry the matted fibres, on blotting-paper, in a warm room, but not near the fire, nor by the aid of steam. When dry, the weight will be found to have increased to from 210 to 220 grains—sufficient for two pints of moderately thick collodion. It is extremely soluble, leaving scarcely a "wrack behind," and in our opinion is superior to anything we have been able to manufacture from any proportions of the mixed acids. Why it is so we cannot explain: we only mention the fact.

We have not in the above remarks said anything about temperature—that most important modifying agent of the photographic properties of pyroxyline. The formula has been purposely constructed so as to do away with that troublesome complication, and to avoid the necessity for precautions with respect to it. The quantities also are given with the same view. But, if any one is curious on the point, by carefully attending to every detail of the above process, he will find that a thermometer immersed in the mixture along with the first tuft of cotton will indicate, invariably, a temperature ranging from 146° to 150° Fahrenheit; and, further, it will not be

found to fall more than one degree during the five minutes' soaking of the cotton. The above temperature is considered the best for a good normal pyroxyline, suited for both the wet and the dry process. But if the cotton has not been well dried, the temperature will be found to rise after its immersion, and, in consequence, the resulting pyroxyline will be somewhat disintegrated in texture, and deficient in weight after drying.

2nd Formula.

WITH STRONG ACIDS.

Sulphuric acid, sp. gr. 1845 . .	12 fluid ounces.
Nitric acid, sp. gr. 1450 . . .	4 „
Water	17 drachms.
Carded and dried cotton wool. . .	270 grains.

3rd Formula.

WITH WEAKER ACIDS.

Sulphuric acid, sp. gr. 1840 . .	12 fluid ounces.
Nitric acid, sp. gr. 1400 . . .	6 „
Water	6 drachms.
Carded and dried cotton wool . .	270 grains.

If the acids be somewhat weaker than the above omit the water altogether, and slightly increase the quantity of nitric acid.

We have never found that extreme purity of the acids is a point of much importance. Provided they be of the right specific gravity, the ordinary commercial kinds answer every purpose exceedingly well, and there is really no occasion to add to the expense of pyroxyline by insisting on the absolute absence of the usual impurities which accompany them. The nitric acid of commerce, for instance, has generally a yellowish appearance from the presence of chlorine, which has some action on the cotton fibre, but not of a prejudicial kind. Neither does a slight evolution of red fumes in the stock bottle seem to have an appreciable effect on the pyroxyline. It only weakens the acid; and therefore it is a useful precaution, as before stated, to keep the bottle in a cool, dry, and dark cupboard for its better preservation.

The manipulations are nearly the same as those connected with the nitrate of potash process described above; but in this case more precautions are necessary to guard against failure. In the first place, the specific gravity of the acids must be accurately determined, in order to regulate the quantity of water to be added. The temperature, too, generated by an admixture of acids of varying concentration with the water, differs very much. Hence it will be

necessary to rely only on the indications of the thermometer as to the proper time for the immersion of the cotton. If the acids are strong the temperature will rise spontaneously higher than the required degree; if weak, artificial heat will be needed. A good plan of procedure in every case, when preparing small quantities of pyroxyline, whether the acids be strong or not, is to fill the glazed earthenware pipkin or *thick* porcelain vessel with boiling water, and allow it to remain for a short time immediately before mixing the acids, in the same way as in the nitrate potash process described above. The thick non-conducting sides of the vessel will retain the heat for a considerable time, and enable the operator to work with the utmost deliberation.

When everything is ready, pour in the nitric acid and water, then the sulphuric acid. Intimately mix them with the thermometer bulb, and note the temperature. When it falls to 150° Fah., immerse the cotton, tuft by tuft, according to previous instructions, and in order that the pyroxyline may be of uniform solubility in ether and alcohol, move it about and pull it out under the acids for six or seven minutes after the immersion of the last tuft.

Wash as before, excepting that in this case the treatment with ammonia is unnecessary, and may be omitted.

Pyroxyline prepared by the above formulæ should, when perfectly dry, show an increase of from twenty-five to thirty per cent. over the original 270 grains. If the action of the acids be continued for ten minutes or more, twenty per cent. of increased weight will be nearer the mark; but we have never found any advantage arising from a more prolonged immersion than that recommended, especially if the completion of the process be facilitated by moving about the cotton when under the acids. It is of importance to notice, that the operation of soaking the cotton should always be conducted in a dry atmosphere, for we have found the percentage of increase in weight to vary considerably, according to the dryness or dampness of the air in the operating-room. From a moist atmosphere the exposed acid mixture greedily absorbs water, and becomes weakened to such a degree as often materially to lessen the weight of the pyroxyline, and also alter its photographic properties. For the same reason the plan often recommended of placing the vessel containing the acids in a pan of warm water is open to objection.

If the pyroxyline be not required for immediate use, a few observations respecting the best method of storing it will not be out of place, because, under many circumstances, it is peculiarly liable to spontaneous decomposition; more so, indeed, than the less soluble and more explosive compounds, in which the peroxide of nitrogen ...ore strongly combined. It will keep perfectly for at

least two years, if the following precautions be adopted:—1st. It must be thoroughly washed and dried. 2nd. It should be stored in a well-ventilated vessel—for instance, it is dangerous to keep it closely pressed together in a stoppered bottle; a thin cotton bag, in which it is loosely stowed away, we have found to answer the best. 3rd. Light, heat, and moisture, facilitate decomposition; stow it away, therefore, in a dark, dry, and cool place.

The first symptoms of deterioration are generally manifested by the evolution of red fumes, which consist of the oxides of nitrogen; but not always so, for we have seen instances of entire decomposition unaccompanied by this appearance. In one case a thoroughly washed and imperfectly-dried sample of very soluble cotton was exposed, in a hermetically sealed tube, to the light. After a few months it had changed its character completely, and was no more suited for photographic purposes. The change was marked by a strong acid reaction, and a partial disintegration of the fibre. In another case a tuft of similar pyroxyline, treated in a test tube with boiling water, exploded with considerable violence, while other samples, equally soluble in ether and alcohol, were gradually decomposed with evolution of red fumes. The instance where explosion occurred was certainly an exceptional one; but it shows how uncertain our knowledge of the composition of this compound still is, after all the research which has been brought to bear on the subject; and it further shows the necessity of great caution in its preparation and stowage for future use.

Quickness of Lenses. The comparative "quickness of lenses," (as it is termed,) depends *partly* on the colour of the glass, the number of glasses in the combination, the number of reflecting surfaces, &c.; but *mainly* on the aperture of the lens, and its focal length.

It is evident that, other things being equal, the intensity of light in the image depends first on the quantity of light admitted, and secondly on the area over which it is distributed. It varies, therefore, *directly* as the aperture, and *inversely* as the size of the picture.

But the size of the picture given by a lens varies directly as the square of its equivalent focal length; and the area of the aperture, or diaphragm, varies as the square of its diameter. Therefore the time of exposure varies *directly* as the square of the equivalent focal length, and *inversely* as the square of the diameter of the aperture or stop.

In the same lens the time of exposure varies inversely as the square of the diaphragm used. For instance, with a diaphragm of

half an inch diameter the time of exposure must be *four* times as great as with a diaphragm of one inch.

Raisin Process. This is one of the multitudinous modifications of the dry processes which are ever cropping up. It was originally described by Dr. Schnauss. It, however, possesses considerable advantage over the other saccharine preservatives which have been from time to time suggested, inasmuch as raisins, besides the sugar, contain a substance analogous to tannin.

The method of preparing the preservative solution is this. Boil one ounce of raisins for about five minutes in ten ounces of distilled water. Set aside to cool; then filter, and apply to the thoroughly washed collodion film as in the tannin process. The development, as usual, is either by the alkaline or acid pyrogallic method.

Ramsden's Eye-Piece. This telescopic eye-piece is used as a focussing magnifier to magnify the image formed on the focussing screen of the camera. It is composed of two plano-convex lenses, equal in all respects, and mounted in a tube with their plain sides outwards, at a distance apart equal to two-thirds of the focal length of either. When using this magnifier, the image on the ground-glass should be nearly in its principal focus. It is used in telescopes when spider-lines are placed in the focus of the object glass. It is sometimes called the Positive Eye-piece, and is not achromatic.

Rapid Dry Processes. These are dry processes in which no longer exposure is required for a dry than for a wet plate. The tannin process, either with a bromised, or a bromo-iodised collodion, and alkaline development is a rapid dry one, and so is the new Fothergill process. When the usual acid developer is used, and a preservative of gum arabic, very short exposures may be given, when the collodion is bromo-iodised; and Dr. Hill Norris's rapid dry plates appear to be prepared on this principle. But in all cases, the presence of bromide of silver appears to be imperatively necessary in a rapid dry plate, however developed. Iodide of silver is extremely insensitive when the free nitrate has been removed from the film. For further information, consult a pamphlet by Mr. Sutton, entitled "Instantaneous Dry Collodion Processes," and published by Messrs. Sampson Low, Son, and Marston.

Realgar. AsS_2. Red sulphide of arsenic. This substance is used in making "White Indian Fire" (*q. v.*). It is easily fused, and sublimed.

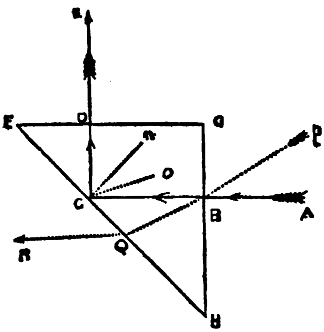
R's Thermometer. In this scale 0° is taken as the

freezing point, and 80° as the boiling point of water. *See* "Thermometer."

Red Heat. 980° Fahrenheit, according to Daniell. The heat of a common fire is about 1150°.

Red Lead. $Pb_3 O_4$. This fine pigment is made by exposing litharge to the action of air at a temperature of about 560, by which it absorbs oxygen and becomes converted into red lead. The brilliancy of the colour is reduced by exposure to light.

Reflecting Prism. Suppose FGH to be a glass prism having equal sides FG, GH, and the angle at G a right angle; and let AB be a ray of light incident at B perpendicularly to the side GH. This ray will not suffer deviation on entering the glass, but will proceed in the same straight line till it comes to C. What will then happen to it?



Draw Cn at right angles to FH, and make the angle nCo equal to the "critical angle" of the glass. (*See* "Refraction.") This angle will lie between 39° and 42°, according to the refractive index of the glass, being the least for flint and the greatest for crown glass. Therefore all the rays within the glass incident at C, and not lying within the angle nCo, will suffer total internal reflexion. Now the angle $nCB=45°$, and is therefore greater than nCo, consequently the ray BC is internally reflected at C, and follows the rectilinear course CDE, CE being at right angles to CA.

It appears therefore that the back of a glass prism may be used as a reflector.

With respect to *oblique* rays incident at B. It is evident that all rays incident at B and lying within the angle ABH will suffer internal reflexion, but between A and G there will be a limit, for a ray PB whose direction BQ within the glass makes an angle BQH greater than oCH, will *not* suffer total internal reflexion, but will pass through the prism in the direction QR. In order for this to happen, the angle PBA must be greater than about 9° when the prism is made of dense flint glass. All rays therefore lying within a space PH, nearly equal to 100°, suffer internal reflexion; and those lying within PG pass through the prism.

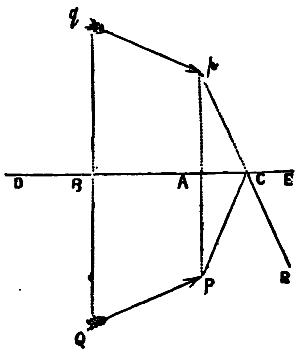
Reflexion. When a ray of light is incident on a polished surface of any kind, it is turned out of its course, and suffers "reflexion."

The law is, that the reflected ray lies in the same plane with the incident ray and the normal to the reflecting surface at the point of incidence; and that it makes with the normal an angle equal to that made by the incident ray, on the opposite side of it, but on the same side of the reflecting surface.

In all cases of reflexion a part only of the light is reflected, the remainder being scattered or absorbed.

Reflexion at a Plane Surface. When a virtual image of a luminous object is formed by reflexion at a plane surface, there is no spherical aberration in the pencils, nor any distortion in the image, and the image is situated in exactly the same relative position with respect to the reflector, *behind* it, as the luminous object in *front* of it. As these points should be clearly understood we shall demonstrate them with the help of a diagram.

Let PQ be a luminous object placed before a plane reflector ED; and let PC be any one of the rays of the pencil proceeding from P. This ray after reflexion at C will follow a course CR such that CR and PC make equal angles with CD. Draw the line PA perpendicular to the plane of the reflector, and produce it to p, making $Ap = AP$. Join pC. Then in the triangles PAC, pAC, which lie in the same plane, $pA = PA$, CA is common to both, and the included angles at A are right angles, therefore the angle $pCA = PCA$. But the angle $ECR = PCA$, and is in the same plane with it; therefore $pCA = ECR$; CR is consequently in the same straight line with Cp. Hence it follows that the reflected ray CR, if produced backwards, passes through p. But the position of the point p does not depend upon the distance AC, or the angle PCA; it is therefore the same for every reflected ray of the pencil from P. Therefore p is the virtual image of P, and the reflected pencil is entirely free from aberration.



In the same way it may be shown that if Q be any other point of the object, and Qq be drawn perpendicular to the reflector, BQ being equal to Bq, q is the virtual image of Q.

Hence it follows that pq the virtual image, and PQ the object,

are symmetrically situated with respect to the plane of the reflector DE, on opposite sides of it.

Refraction. When a ray of light passes out of one transparent medium into another of different density it is bent out of its course, and suffers deviation.

The law is, that the refracted ray lies in the same plane with the incident ray and the normal to the surface at the point of incidence; and that it lies on the opposite side of the normal, and makes with the normal an angle of refraction the sine of which bears to the sine of the angle of incidence a constant ratio, depending on the nature of the two media.

When refraction takes place from vacuum into a medium, this constant ratio is called the "refractive index" of the medium, and is generally denoted by the Greek letter μ. It is always greater than unity.

If then, ϕ be the angle of incidence
ϕ' „ refraction
the law of refraction is expressed by the equation.

$$\text{sine } \phi = \mu \text{ sine } \phi'$$

which is called the "Law of Sines."

The sine of an angle is a decimal fraction less than unity, and may be found by consulting a table of natural sines. The sine of $0° = 0$; of $90° = 1$; of $30° = \cdot 5$; and so on. *See* "Sine."

Suppose then the refractive index of a piece of glass to be 1·54, and the angle of incidence of a ray upon its surface to be 37° 18′; required to find the angle of refraction.

By consulting the table we find that the sine of 37° 18′ = ·60599:—

$$\text{Therefore } \cdot 60599 = 1{\cdot}54 \times \text{sine } \phi'$$

which gives sine $\phi' = \cdot 3935$.

Consulting the table again we find that ·39341 is the natural sine of 23° 10′, and ·39367 the natural sine of 23° 11′; therefore the angle of refraction, ϕ' is equal to 23° 10′ 20″.

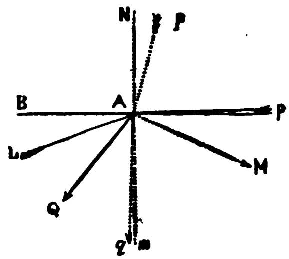
The following table gives the value of μ for a few different substances.

Chromate of lead	2·974
Diamond	2·439
Nitrate of silver	1·788
Flint glass	from 1·625 to 1·58
Crown glass	from 1·542 to 1·514
Canada balsam	1·55
Castor oil	1·49
Turpentine	1·475

Nitric acid	1·41
Alcohol	1·372
Acetic acid	1·36
Ether	1·358
Water	1·335
Air	1·000276

We have now to consider the case of a ray about to pass from a dense medium into a vacuum.

A ray of light on having its direction reversed returns by the same path as that by which it came; so that if PNB be a vacuum, PnB a dense medium, and pAq the bent course of a ray proceeding in the direction of the arrow, if this ray be reversed and turned back it will follow the course qAp. If then the angle pAN$=\phi$, and qA$n=\phi'$, the equation sine$\phi=\mu$sineϕ' becomes sine $\phi'=\frac{1}{\mu}$ sine ϕ.



If ϕ' be such that $\phi=90°$, sine ϕ' will be equal to $\frac{1}{\mu}$; and the angle whose sine is $\frac{1}{\mu}$ is called the "Critical Angle."

Suppose, now, PA to be a ray whose angle of incidence differs from 90° by a quantity less than any assignable quantity; it will then after refraction follow the course AQ, and QAn will be the "critical angle." This angle for plate glass is about 42°, and for flint glass about 39°, therefore less than 45° in both cases.

Now observe what follows:—

Any ray within the dense medium, proceeding towards A and lying within the angle nQ, will emerge and take a direction somewhere within the angle PN; *but no ray incident at* A *whose direc-*
lies within the angle QB, *will be able to get out of the glass,* will suffer total reflexion, as shown in the figure by the ray M; the angle LAn being equal to the angle MAn.

he meaning and importance of the critical angle will now be for the inner surface of a transparent medium may be-
lly reflecting surface; and a block of transparent glass

may be as perfectly opaque to light as a sheet of iron. It is on this principle that the reflecting prism is constructed; (*q. v.*)

Refractive Index. See the preceding Article.

Practical opticians generally determine the mean refractive index of their glass by making it into a lens of known surfaces, and finding by trial the focal length of the lens.

A more scientific way is to make it into a prism of small angle, decompose a ray of white light through it, close to the edge, and at the angle of minimum deviation; receive the spectrum upon a telescope, and measure the deviation of a ray corresponding with a certain dark line of the spectrum, by means of a suitable instrument furnished with verniers.

The different coloured rays of the spectrum have different refractive indices, that for violet being the greatest, and for red the least.

Rennet. The stomach of the calf, salted and dried. It is used for curdling milk. *See* "Whey," and "Casein."

Residues. The recovery of gold and silver from waste solutions is of the utmost economic importance to the practical photographer, because thereby he may save more than half the value of these expensive and indispensable substances.

To recover Silver from Nitrate Solutions:—First Stage. Precipitate the silver in the shape of chloride, either by means of common salt or hydrochloric acid. The washings from silver prints before toning, should also be so precipitated. They contain a large quantity of silver which has not been reduced by light. The waste developing solutions which have played their part in developing negatives, may also be thrown into the same stock-jar, and the clear supernatant liquor drawn off when the silver salts have subsided. Another jar should be kept for cyanide and hyposulphite solutions used for fixing negatives and positives. In these the silver is not in a state of combination to be precipitated by chloride of sodium. The best plan to adopt is to precipitate it by means of "liver of sulphur" (sulphide of potassium), in the shape of a sulphide. This jar should not be kept indoors, and especially not in any place dedicated to photographic operations, because of the offensive and deleterious sulphurous fumes which are given off.

Clippings from unfixed photographic prints should also be carefully preserved; when burnt the ash will contain from sixty to seventy per cent. of silver.

When a sufficient quantity of chloride, sulphide, &c., of silver, and ashes of clippings have accumulated to make it worth while reduc-

ing them, they should be mixed together and dried in a porcelain dish in an oven. The dried mass may then be sold to the refiner, who will reduce it to the metallic state at a trifling cost, or give value for it after testing its richness in metal.

Some photographers in extensive practice reduce their own waste silver residues. This is easily accomplished in various ways. The following is very efficient:—Pound up the dried residues with twice their weight of nitrate of potash (saltpetre) and half their weight of wood charcoal. Place a large Hessian crucible on the fire, raise and maintain it at a bright red heat. Throw in the powder spoonful after spoonful as each deflagrates. Finally raise the crucible to a white heat and allow it to cool, when the silver will be found reduced to a metallic button, or to a sponge-like form, if the heat has not been finally raised sufficiently high. If the mass or spongy particles be again fused without saltpetre or charcoal, nearly pure silver will be obtained, unless gold has been mixed up with the waste residues. But this latter is of no consequence if the silver thus prepared has to be again converted into nitrate, because gold is not soluble in nitric acid.

To Recover Gold from Waste Solutions. The terchloride is the only gold salt that is used in Photography. Toning baths containing it, when they have ceased to be active, still contain a considerable proportion of the precious metal. This is reduced to the metallic state in the form of a blueish-black powder by proto-sulphate of iron. The precipitate also contains carbonate and oxide of iron. When a sufficiency of precipitate has been collected, sell it to the refiner, or proceed to reconvert it into chloride of gold by the following process:—Digest it in a glass beaker on a hot sandbath in 4 parts hydrochloric acid, 1 part nitric acid, and 8 parts water, for about half an hour; then raise the mixture to the boiling point, and when cold filter out the undissolved residue, which is principally chloride of silver and organic matter. All the gold is contained in the filtered liquor, and may now be again thrown down in a pure state with solution of proto-sulphate of iron; wash the precipitate in dilute sulphuric acid, and then in several changes of water. Fuse the powder into a button, or convert it into chloride of gold with *aqua regia*. *See* "Gold, Chloride of."

Resin Process. This dry process was suggested many years ago by the Abbé Pujo. It is perhaps the simplest of all dry processes, because the organic preservation is added directly to the collodion, and no farther trouble than washing the film after it has been sensitised is necessary.

In ordinary bromo-iodised collodion, dissolve half a grain of common resin (that used for fiddle bows) to each ounce. Coat, excite, and wash the plate as usual. When dry, it is fit for the camera.

The only disadvantage connected with this process, apart from its inferior sensitiveness as compared with the tannin, is that it is very apt to put the nitrate bath out of order.

Resins. Resinous substances are an abundant vegetable product, and are frequently obtained by making incisions in the bark of trees. In some cases the resin, which is then called a "balsam," occurs mixed with volatile oil, which either evaporates or becomes oxidised and resinified by the action of air and light. In other cases it occurs mixed with gum, and is then called a gum-resin. Bitumens and fossil resins are supposed to be products of antediluvian vegetables.

Most of the resins are soluble in anhydrous alcohol, and many of them in ether, sulphide of carbon and the oils.

The alcoholic solutions of some of the resins are acid, of others neutral, and of others alkaline. Ammonia does not precipitate the acid solutions, but forms with them an ammonio-alcoholic solution, which in general precipitates a white powder on the addition of nitrate of silver.

Acetic acid, and also nitric acid, dissolve many of the resins.

Common resin, or Colophony, is the residue of the distillation of turpentine. It contains water at first, and is then yellow. When deprived of this by fusion it becomes black

Some of the resins are of great use in making varnishes. *See* "Varnish."

Restrainers. This term is generally used in Photography to denote those substances which act on the developer by curbing its violent action. Acids, gelatine, and some other organic bodies, act in this capacity. They prevent the deoxydising agent from depositing silver on those parts of the collodion or other sensitive film, which have not been impressed by light. All developers, unless restrained, exhibit this tendency in the presence of a soluble salt of silver.

Reverse Action of Light. Sometimes those parts of a negative which should be the most opaque, come out perfectly transparent through over-exposure. This is called the "reverse action of light." It happens most frequently when the bath is acid with free nitric acid. Solarisation, in all the process, may be considered as the first step towards this extreme action of light upon iodide of silver, and

if the exposure were sufficiently continued, the complete effect of the reversion of the lights and shades would probably occur in all cases. This reversion may be produced by exposing a plate to diffused light for a second or two after pouring on the developer.

If the latent or invisible image upon iodide of silver be produced by actual reduction by light (which is possible), then it is not difficult to understand how over-exposure may carry the reduction to such a stage as that the reduced material may cease to be a substance for which the decomposing pyrogallo-nitrate has an affinity. If, by the excessive action of light, the developable material in the sensitive film be reduced nearly to the *metallic* state, then it is easy to conceive that it could not be intensified (for we know how difficult it is to intensify the metallic precipitate of a glass positive). At any rate, this appears to be the most plausible way of accounting for the "reverse action of light," as it is improperly called.

Rice Water. This is sometimes added to the iodising solution in the waxed-paper negative process. It is made by boiling whole rice in water for a few minutes and then straining the liquid. The proportions are quite empirical, and the operation of very questionable utility. Serum of milk is a much better organic substance to add to the iodising solution when it is required to obtain the effects due to organic matter.

Rock Crystal; Quartz. This may be considered as pure silica. It occurs in fine large six-sided prismatic crystals, which are extremely hard. The finest specimens come from Madagascar, and the Alps; the Bristol and Cornish diamonds are also good specimens. Rock crystal is used for spectacles, and sometimes for lenses. It has about the same refractive index as glass, and is beautifully transparent, and very cold to the tongue.

Rotten Stone. A mineral found in Derbyshire. It is reduced to fine powder, and used for polishing metals, daguerreotype plates, &c. When used for the latter purpose, it should be sifted upon the plate through a fine muslin strainer.

Rouge; Colcothar; Crocus. Red oxide of iron. Used for polishing glass, metals, &c.

It is prepared thus:—

Make a boiling solution of sulphate of iron, filter it, and add to it a concentrated solution of oxalic acid; this throws down yellow oxalate of iron. Wash the precipitate, and heat it, while still moist, upon an iron plate, over a charcoal fire. At a temperature of about

400° the salt is decomposed, and brown-red peroxide of iron, or "rouge," formed in a very finely divided state.

Daguerreotype plates should not be polished with rouge, because the iron clings to the silver and injures the tone of the picture.

Roughening the Edges of Glass Plates. The edges of the glass plates used for negatives, &c., should be roughened, otherwise they are apt to cut the fingers and the cloths used for wiping and polishing them. The sharp edges can be blunted either by means of a fine steel file, a common scythe stone, by corundum, or by rubbing the edges against each other.

Round Front Camera. One in which the lens is mounted upon a slide in front, which, instead of being flat, is the segment of a cylinder, of which a horizontal line through the centre of the picture is the axis. When this camera is used, the plane of the picture must be always vertical. It is a very simple plan for obviating the use of a swing back, and is the invention of Mr. Sutton.

Saltpetre. *See* "Nitrate of Potash."

Salts are compounds of acids with an alkali or salifiable *base*, or of the halogens with a metal. The first group comprehends all the metallic and some other oxides combined with an acid; the second group comprehends those substances in which the haloid elements, such as bromine, chlorine, &c., are combined with the metal, &c. In every case the names of the salts are derived from the acids which enter into their composition, followed by the distinctive name of the oxide or element with which they are combined.

Sandarach. Juniper resin. A resin much used in varnishes, and the produce of the *Thuia articulata*, which grows in Barbary. Sandarach usually occurs in small yellow drops, easily fusible, and soluble in alcohol.

Saponification. Soap is a combination of a fatty acid contained in oil with a strong alkali. The principal acids contained in oils are, the stearic, margaric, and oleic; and when existing in oils they are combined with a peculiar base called "Glycerine," (*q. v.*) or oxide of glyceryle; so that when an oil or fatty substance is boiled with a strong alkali, as soda or potash, the feeble base glycerine is displaced by the more powerful one, and the results are soap and glycerine. This is the theory of saponification.

Sayce's Process. Mr. Sayce, in order to avoid the complication of using a nitrate of silver bath for negatives, has suggested and

practically carried out a process in which bromide of silver is suspended in the collodion. The results are very promising indeed, so much so, that it is probable his method, or some modification of his method of working, may come into extensive use by dry plate photographers, and possibly also in the wet process. The following are his instructions, published in the "British Journal of Photography."

I. Preparation of the Collodion.

Take bromised collodion, containing eight grains of bromide in each ounce. Say—

Bromide of cadmium	6 grains.
" ammonium	2 "
Soluble pyroxyline of fair ordinary quality	6 "
Ether	½ ounce.
Alcohol	½ "

Prepare as much as may be required, and, when mixed, allow it to stand for a week, and then pass through a retort filter.

When the above bromised collodion is ready for use, take crystallised nitrate of silver eleven grains, reduce it to a fine powder in a glass mortar, and then add one or two drops of water, or say sufficient to produce a kind of pulp; then, in a yellow or non-actinic light, mix the collodion with the silver, stirring with a glass rod or pestle as the mixture is being poured into the bottle intended for its reception; then shake up well, and allow to stand.

II. Use of the Collodion in a Wet State.

Take a perfectly clean plate of glass free from scratches, tip the edges for an eighth of an inch with a solution of one grain of india-rubber in one ounce of benzine, and then coat with the collodio-bromide of silver; allow to set the usual time, and place in a dish of water until the greasy appearance has vanished.

If warm water can be obtained conveniently, use it in preference, there being a great saving in time, and the plates are more sensitive. When the water flows freely over the film, take the plate out of the dish, wipe the back, and drain for a moment upon a piece of blotting-paper; then place in the dark slide for exposure in the camera. Expose a little longer than wet collodion with a nitrate bath. Before development, wet the film with a little water, and pour over—

Protosulphate of iron	25 grains.
Glacial acetic acid	25 minims.
Water	1 ounce.

To three drachms of this add two drops of solution of nitrate of silver, twenty grains to one ounce of distilled water.

The image appears quickly, and in every respect like an ordinary wet plate. A few trials will show the proper exposure.

Intensification may be accomplished by any of the methods adapted to wet plates, and the fixing with cyanide of potassium, twenty grains to the ounce of water.

III. Use of the Collodio-Bromide of Silver in the Preparation of Tannin Plates.

Coat a clean plate of glass, previously tipped at the edges (with india-rubber in benzine), with collodio-bromide of silver, and when the film has set, place it in a tank of water; then coat another plate, which also place in the tank, and so on until the number required has been completed.

Then have ready a dish of water from the kettle, as hot as the hand can bear. Take the plates out of the tank in rotation, and just pass them through the hot water for a few seconds, then place them in a bath of tannin solution, fifteen grains to the ounce of water, well filtered; or in the following solution—suggested to me by Mr. Verity, of Manchester—which I find superior to the ordinary tannin solution, viz.:—

Tannin	10 grains.
Gallic acid	5 „
Water	1 ounce.
Grape sugar	5 grains.
Alcohol	10 minims.

Prepare *quantum suff.*, as follows:—Dissolve the tannin in a portion of the water, and filter; dissolve the gallic acid by heat in another portion, and, when filtered, mix with the tannin, then add the grape sugar, and again filter; the alcohol may now be added, and it is ready for use.

If the plate be allowed to remain in the above solution *three minutes*, and properly exposed, very little intensification will be found necessary. When ready, take out the plate, and drain and *dry evenly* and *quickly* in any convenient but suitable manner. Expose about one-half the time required for tannin plates with bromo-iodised collodion.

Development.—Prepare as much as required of the following solutions:—

No. 1.	Alcohol	½ ounce.
	Water	½ „

No. 2.	Carbonate of ammonia	40 grains.
	Water	20 ounces.
No. 3.	Pyrogallic acid	96 grains.
	Alcohol	1 ounce.
No. 4.	Bromide of potassium	5 grains.
	Water	1 ounce.
No. 5.	Nitrate of silver	30 grains.
	Citric acid	15 „
	Distilled water	1 ounce.

Pour over the dry plate, once or twice, sufficient of No. 1 to cover it, and then return to the bottle for use with the next plate.

Then place in a dish of water until the greasy appearance has vanished.

Then pour over, evenly, sufficient of No. 2, with a few drops of No. 3, and two drops of No. 4 added, and wave to and fro with a rocking motion.

The image should very soon appear, and may be developed until the shadows become slightly tinged; then wash the surface and back of the plate freely with water, and rinse the surface and back with a little dilute acetic acid (say two drops glacial acid to one ounce water); wash off the acid, and if any intensification be required, it may be effected by adding—to, say, two drachms water—three drops of No. 3 and three drops of No. 5 solutions.

The use of the bromide in the developer is *merely to prevent fog*, should such arise, *but it is often found* that the development can be conducted without the evil appearing; *such being the case*, it *is better to avoid using bromide in the developer*. When sufficiently dense, wash and fix with cyanide, of the same strength as for wet plates, and wash thoroughly afterwards.

Fixing with strong cyanide tends to counteract any tendency towards splitting of the film on drying.

When experience is gained in working the process, the quantity of nitrate of silver in the collodion may be increased to twelve or even thirteen grains, accompanied by greater sensitiveness in the prepared plate.

Sealing Wax. The best sealing wax is made with shellac, or dammar, the inferior sorts with common resin.

The following are the compositions of the best kinds of coloured sealing wax:—

Red Sealing-wax—

Shellac	2lbs.
ˉnice turpentine	1lb.
milion, or sub-chromate of lead .	½lb.

Black Sealing-wax—

Shellac	2lbs.
Venice turpentine	1lb.
Lamp black	½lb.

Melt the shellac and turpentine together with heat, and add the pigment as the mixture cools.

Common black bottle wax is made thus:—

Black resin	6lbs.
Bees' wax	½lb.
Lamp-black	1½lb.

Neither Venetian red nor red-lead should be substituted for lamp-black, because the latter is inert, and not acted on by chemicals.

Sea-Water. Sea-water has been sometimes used in Photography instead of a solution of common salt. The composition of the water of the English Channel, according to the analysis of Schweitzer, is as follows:—

Water	964·74372
Chloride of sodium	27·05948
——— potassium . . .	·76552
——— magnesium	3·66658
Bromide of magnesium . . .	·02929
Sulphate of magnesia	2·29578
——— lime	1·40682
Carbonate of lime } ——— magnesia } . .	·03301
	1000·00000

Sea-water contains, therefore, about 16 grains of chlorides to the ounce of water. When used for positive-printing it would therefore, in general, require to be diluted with an equal bulk of fresh-water.

The water of the Mediterranean contains a trifle more saline matter than that of the English Channel.

The clamminess and stickiness of sea-water is due to the presence of the magnesium salts. Its average specific gravity is 1·027; and the average of its saline contents 3½ per cent.

Seed-Lac. *See* "Lac." Seed-lac is said to be more soluble in alcohol than shellac, and therefore to make clearer varnish.

Sepia. (Gr. σηπια, a cuttle-fish.) Sepia is a fine, rich, brown pigment, obtained from the black liquid which is ejected by the

cuttle-fish, in order to darken the water when pursued. The sac which contains the colour is extracted from the fish, and the juice dried as quickly as possible.

The colouring matter consists of carbon in an extremely divided state, along with albumen, gelatine, and phosphate of lime. The brown colour is obtained by acting on it with a caustic alkali.

Sepia may probably be found a valuable pigment for the printing processes in carbon and pigments, in which bichromate of potash is used as a mordant when reduced by light.

Sepometer. (Gr. σηπω, to putrefy.) An instrument invented by Mr. Angus Smith for determining, by means of the decoloration and decomposition produced in permanganate of soda, the amount of organic impurity existing in the atmosphere of towns. These organic impurities in the atmosphere no doubt considerably affect photographic operations, and the photographer should not be without the means of testing their presence. The aqueous solution of permanganate of soda is of a purple colour, and is decolorised by agitating it in contact with air containing ammonia, sulphuretted hydrogen, and sulphurous and phosphorous acids. It is also decomposed by organic matter, being a powerful oxidiser.

Serum of Milk. Serum, or whey, is the watery liquid which remains after the cream and cheese have been removed from milk. It contains a sugar called sugar of milk and some soluble salts, also a small quantity of uncoagulated casein. It is of great use in photographic printing upon plain paper for giving surface vigour to the proofs without any disagreeable glazed appearance;—and in the paper negative process it seems to act better than any other substance in giving density to the blacks, probably from the presence of the salts of lactic acid which it contains.

The simplest and best mode of making whey for the paper processes is to add lemon juice to skimmed milk in the proportion of about 2 spoonfuls of lemon-juice to a quart of whey. Boil them together and strain the liquid through a cloth, which separates it from the curd. It should be of a greenish colour and slightly opalescent. About 6 grains of salt may then be added for positive printing paper, and about 5 grains of salt and 10 of iodide of potassium for negative paper. The acidity of the whey thus prepared preserves the whites of the paper beautifully.

Whey may also be made by adding a piece of rennet about 3 inches square to a quart of skimmed milk, and putting it in a basin on a hob so as to raise the temperature to about 120°. In half an hour

or so the curd is formed. This is called sweet whey, from its not being so acid as the other. It contains rather more casein.

Silver. Ag.=108. The Luna, or Diana, of the alchemists.

This valuable metal occurs native and also in a variety of combinations, but principally as sulphide. It is chiefly found among primitive rocks. The richest mines are in Peru and Mexico, and the richest in Europe are those of Saxony, Bohemia, Swabia, and that of Konigsberg in Norway.

Pure silver has a specific gravity varying from 10·4 to 10·6, according to whether it is cast or rolled. It does not oxidise in the air, but is peculiarly liable to be acted on by sulphurous fumes from common coal gas, or from sulphuretted hydrogen existing in the atmosphere, which blacken it. When the pure metal is alloyed with copper this action takes place more rapidly, but no doubt this is owing to the copper with which it is alloyed being acted on by the oxygen of the air. Pure silver is both very malleable and ductile, and melts at a bright red heat. Water has no action on it unless it contains sulphur, either free or in combination. When exposed to a white heat in an open crucible it volatilises. Indeed, there is good reason to suppose that it volatilises slowly at a lower temperature when in a state of fusion.

What is called "standard silver," is an alloy of it with copper, containing 92·5 per cent of silver. From this alloy pure silver can easily be produced. *See* "Silver, Nitrate of."

Silver, Acetate of. $Ag\,O, C_4\,H_3\,O_3 = 167$. Is a salt of silver only slightly soluble in water. Paper impregnated with it is sensitive to light; but the only practical purpose to which it has been applied is to the sensitising of wood blocks, on which copies of negatives have thus been impressed by a long exposure to light, the pictures being sufficiently marked to guide the engraver in the outlines and shading of his drawing. It has been by some recommended to add acetate of silver to the negative nitrate bath for the purpose of increasing the density of the negative. Avoid such advice, unless in the way of experiment.

It may be prepared in crystals by adding a concentrated solution of 137 parts of acetate of soda, to a concentrated solution of 170 of nitrate of silver. The concentration in both is for the purpose of saving silver, because if much water were employed, the whole of the acetate of silver itself might remain in solution.

Silver, Albuminate of. The white precipitate which falls when albumen is added to a solution of nitrate of silver is called by this name. It would imply that it is a neutral salt of albuminic acid and

protoxide of silver; but there is not sufficient proof that the silver exists in it in the state of protoxide in combination with a normal acid body. Albumen is alkaline, and an animal substance of a very complex nature, containing even inorganic salts essential to its constitution. It therefore undergoes decomposition in contact with nitrate of silver, and all that can be said is, that the precipitate contains organic matter and some oxide of silver, of which the former acts the part of an acid, and the latter of a base.

Silver, Ammonio-nitrate of. Chemists give this name to a white substance composed of 100 parts of nitrate of silver, and 29½ of ammonia; but in Photography it is either a solution containing oxide of silver, nitrate of ammonia, and ammonia, or oxide of silver and nitrate of ammonia alone. It is used in "printing," *q.v.*

Silver, Bromide of. $Ag\ Br = 188$. This salt is now much used in Photography, especially in the dry processes. It may be prepared by a direct union of the two elements, or, as is more generally the case, by mixing nitrate of silver with an alkaline bromide, when, by double decomposition, the silver and the bromine combine, leaving the acid to combine with the alkali.

Bromide of silver is insoluble in water; soluble in alkaline hyposulphites, cyanides, sulpho-cyanides, and in strong ammonia. By exposure to light it darkens to a tawny grey, although like other haloid salts of silver it is capable of yielding by development a visible from an invisible impression made in the camera. In the solar spectrum, a glass plate or piece of paper coated with bromide of silver is sensitive to light as low as the green, whereas the iodide of silver sensitive medium is barely sensitive below the blue space. Yet it is doubtful whether the employment of a bromide in collodion gives the photographer a superior power in delineating green objects, or others of a colour still lower in the spectrum. Conjoined with the iodide of silver the bromide unquestionably gives a greater free- ...om stains in the negative, and a higher sensitiveness to weak ...s. The reason why is not very apparent from any direct ...a experiments, although the fact is well known that the ...green leaves, ivy, for instance, can be equally well rendered ...iodide as by the bromide of silver. Nature's tints, as pre... to the eye, are not homogeneous like the spectrum. They ...a portion of the white solar light, which gives them colour; ...is this reflected light which acts, as in the case of green, yellow, ... the sensitive film of iodide or bromide. Without this ...ic light, neither iodides nor bromides would be of ...hotography.

Silver, Carbonate of. Ag O, $CO_2 = 138$. This salt is of a white colour, and is formed when a soluble carbonate is added to a solution of nitrate of silver. It is sparingly soluble in water, but easily dissolved by ammonia, hyposulphite of soda, and other *fixing* agents. Nitric, acetic and many other acids dissolve it, forming nitrates, acetates, &c., of silver. It is sensitive to light.

Silver, Chloride of. Ag Cl.$=143\cdot5$. Formed by the direct union of silver with chlorine, or by precipitation when a soluble chloride is added to nitrate of silver or other soluble salt of silver, and of essential service in Photography. It is perfectly insoluble in water, ether, and alcohol; but soluble in alkaline chlorides, hyposulphites, cyanides, sulpho-cyanides, bromides, iodides, &c., and in ammonia. When chloride of silver is dissolved in this manner, it is no longer chloride, but hyposulphite, cyanide, or as the case may be, the chlorine going to the alkali. It is also soluble to a minute extent in nitrate of silver. At 500° of temperature it fuses and concretes into a substance grey and semi-transparent, resembling horn. It is reduced to the metallic state by fusion at a bright red heat, when mixed with twice its weight of potash, or soda, or the carbonate of either; also by boiling with potash in solution, especially when sugar is also present; and by zinc, tin, lead, iron, copper, mercury, and some other metals when moist, and more quickly when hydrochloric or sulphuric acid aids the decomposition by its conducting power, for the force in these cases is that of electrolysis. Zinc filings triturated with moist chloride of silver decompose it with such heat that the zinc and metallic silver fuse together.

Chloride of silver is said by some to be decomposed by light without the intervention of other elements: but this view is not at present supported by sufficient evidence. When decomposed by sunlight in the presence of water, chlorine has been spoken of as existing free in the water, and if this be correct then it is a proof that the water was not the cause of the decomposition, but if it exists in the water in the form of hydrochloric acid and not chlorine, then it is a proof that water took part in the change. That hydrochloric acid is formed and oxygen liberated cannot be denied, but it is said some chlorine is also found in the free state, but no satisfactory proof of this has been produced. Chloride of silver has been decomposed by light in an atmosphere of chlorine, but in that case the experiment was tried on the salt as formed in the pores of paper which contains hydrogen. Niépce found it to be discoloured in vacuo when bitumen and other organic matters which in the air are

decomposed by light remained intact; but a perfect vacuum is not attainable, and chloride of silver is much more sensitive than bitumen. When presented to light under sulphuric acid in a stopped bottle, quite full, no change takes place; and that the acid, as such, does not prevent its discolouration is proved by the fact, that the change goes on if the stopper of the bottle be removed, so that air can reach the surface of the acid. If air, or moisture rather, can act on the chloride through the sulphuric acid we may well suppose it can in an imperfect vacuum. Chloride of silver will thus be reduced by light even under strong nitric acid. It has been given as a proof that it is directly decomposed, that it blackens when carefully freed from moisture and exposed under benzole in a tube from which the air is expelled by boiling the benzole. But benzole contains hydrogen, and is very much inclined to unite with chlorine: this only shows that if the benzole were pure the chloride can be decomposed without being oxidised: and that it is not oxidised in these experiments is also shown by the accumulation of oxygen, above the water, in the bottles in which they are conducted. Pure isolated chloride of silver appears therefore to be not decomposable by light: and the presence of hydrogen, or a body having affinity for chlorine, seems essential to its decomposition. The part of the spectrum which acts on chloride of silver includes the rays from the green towards the violet, to a space quite beyond the visible spectrum: the portion from the green to the extremity of the red, collected to a focus so bright that the eye can scarcely endure it, will not discolour chloride of silver exposed to it for hours. The point of maximum effect is even beyond the violet end.

The reduction which takes place on chloride of silver by the action of light is first into the sub-chloride, and finally, by long continued action, into metallic silver. There is, however, still some difference of opinion on this subject.

Silver, Citrate of. $3\ Ag\ O, C_{12}\ H_5\ O_{11} = 113$. This white salt is formed when a soluble citrate is added to nitrate of silver. It is capable of reduction by light. Hence it is useful in Photography.

Citrate of Silver Printing Processes. These processes only differ from the other printing processes in the composition of the salting th, in which citrate of soda is substituted for a portion of the salt. e exact proportions will depend upon the kind of effect which it lesired to produce. The effect of adding citrate of soda to the ting bath is as follows:—

When a paper containing citrate of soda is floated upon a bath of

nitrate of silver, a double decomposition takes place, nitrate of soda and citrate of silver, together with excess of nitrate of silver being produced. Now, citrate of silver is sensitive to light, and is darkened to a red citrate of the suboxide of silver by exposure to light. This organic subsalt of silver is very energetic in producing the various photographic effects due to organic matter in combination with silver. It reddens the tint of the proof, and renders it more vigorous on the surface, and less liable to assume a cold inky tint in the toning bath. But at the same time it renders the paper less sensitive, a fault which is of no consequence when the light is good. On the whole, therefore, the use of citrate of silver in the printing processes may be considered an improvement, when it is required to produce a certain class of effects.

Silver, Cyanide of. Ag C_2 N or K Cy = 147. Is formed when an alkaline cyanide is added to nitrate of silver. The salt is nearly white, and is sensitive to light. Its use was at one time recommended in some of the "calotype processes," but more extended experience has shown it to be inferior to other salts now generally adopted.

Silver, Fluoride of. Ag F = 127. This compound is formed when an alkaline fluoride, such as that of potassium, is added to nitrate of silver. It has been recommended by M. Le Gray and other waxed-paper authorities, to add fluoride of potassium to the iodising bath. *Cui bono?* Although fluoride of silver is sensitive to light, it is soluble in water. Hence the sensitive salt must be removed when the sensitised paper is washed, as it must be, in several waters.

Silver, Hyposulphite of. Ag O, S_2 O_2 = 164. This salt is formed when a solution of a soluble salt of silver, such as the nitrate, is added to hyposulphite of soda. It is so extremely easily decomposed that it is very difficult to procure it in this way, unless the hyposulphite be very concentrated, and the nitrate solution weak. Even then some sulphide of silver is formed, from which it can be separated by ammonia, which does not dissolve the sulphide. It is then precipitated by neutralising the ammoniacal solution with nitric acid.

It is more easily prepared by dissolving freshly made chloride of silver in a solution of an alkaline hyposulphite till saturation ensues, when the silver salt will fall in white gritty particles. It is insoluble in water, but soluble in hyposulphite of soda, which forms with it double salts. A very moderate heat (about 150° Fahrenheit),

the faintest trace of any acid, and other substances, decompose it into sulphide of silver and sulphuric acid, thus :—

$$Ag\,O,\,S_2\,O_2 = Ag\,S + SO_3.$$

It is this decomposed substance which is so often fatal to the beauty and stability of photographic prints. If a print, when taken from the pressure frame, is placed in a *very weak* solution of hyposulphite of soda, the corresponding silver salt is formed from the nitrate and chloride in the paper; but if the alkaline hyposulphite be not strong enough to dissolve the silver hyposulphite as soon as it is formed, then the latter rapidly decomposes, forming brownish yellow patches of sulphide of silver on and in the paper, which cannot be removed without destroying the proof. For this reason prints should always be washed clear of all the free nitrate which they contain before being subjected to the toning and fixing baths. The chloride of silver with alkaline hyposulphite is not so easily decomposed.

Silver, Iodide of. Ag 1=235. Iodine and silver combine directly, and produce iodide of silver; for, if a silver plate be placed in a bottle containing iodine, and left for a short time, it is tarnished with a yellow film of iodide of silver. If the experiment be made in the dark, and the tarnished plate exposed to light, either under a negative or in a camera obscura, and then submitted to the fumes of mercury, an image is developed, which proves that silver tarnished with iodine is sensitive to light.

Iodide of silver may be obtained by double decomposition, by adding a solution of nitrate of silver to a solution of an alkaline or metallic iodide, such as iodide of potassium or cadmium. The oxygen of the oxide of silver in the nitrate goes to the metal and forms potash or oxide of cadmium; this is converted into nitrate of potash or cadmium by the nitric acid, which leaves the silver, and the iodine combines with the silver to form iodide of silver, which is a yellow insoluble amorphous substance. When the nitrate of silver is in excess, the precipitate is of a strong yellow colour, and is darkened very quickly to a pale brown or greenish tint by exposure to light; but when the iodide of potassium is in excess the colour of the precipitate is rather paler, and is not visibly changed by light.

Till recently it was always supposed that pure iodide of silver was insensitive to light; but Mr. M. Carey Lea, of Philadelphia, has proved that it is sensitive, but not to so great a degree as when combined with free nitrate.

Iodide of silver, with nitrate of silver in excess, is the most sensi-

tive to light of all compounds at present known, and is therefore used in the negative processes of Photography. It is darkened more rapidly in vacuo than in air, and is also darkened to a coffee colour by being boiled for some minutes with distilled water. When iodide of silver is obtained by double decomposition in the manner described, with nitrate of silver in excess, the nitrate of the alkali or metal also formed in the solution, and from which the precipitated iodide of silver is not thoroughly cleared, affects to some extent the properties of the iodide; for instance, when nitrate of potash remains, which is a neutral salt, the iodide is more quickly darkened than when nitrate of cadmium, which is an acid salt, remains.

Iodide of silver is insoluble in water and alcohol, and in ammonia. It is soluble in concentrated solutions of the alkaline chlorides, bromides, and iodides, and also in hyposulphite of soda, cyanides and sulpho-cyanides, forming in every case a soluble double salt of silver and the alkali. Concentrated nitric and sulphuric acids also decompose it. It may be reduced by metallic zinc, forming soluble iodide of zinc, and metallic silver as a black powder. When iodide of silver is fused at a red heat, it acquires a red colour. It volatilises before the blow-pipe, leaving a little silver only behind.

When iodide of silver is dissolved in concentrated solutions of an alkaline iodide, bromide, or chloride, the double salt formed is only soluble in the quantity of water used; if more be added the solution immediately becomes milky. This effect does not happen when either hyposulphite of soda or cyanide of potassium is used as the solvent.

Silver, Nitrate of. $Ag\ O, NO_5 = 170$. This is one of the most important salts at present used in Photography. It is obtained in its purest form by dissolving pure silver in diluted pure nitric acid, evaporating and crystallising, and then redissolving and recrystallising. The salt is then neutral to test paper. Commercial nitrate of silver is made by dissolving silver coins, or silver plate, in nitric acid, evaporating and crystallising, washing the crystals with nitric acid, and then redissolving and recrystallising. The alloy of copper and other metals is not completely got rid of in this way. Commercial nitrate of silver is sometimes, although we must say rarely, adulterated with the nitrates of potash, zinc, lead, &c. Impure nitrate of silver is one of the greatest evils with which the photographer has to contend, and his best remedy is to precipitate the chloride by adding salt to the solution of impure nitrate, then to reduce the chloride, by fusion in a crucible with twice its weight

of carbonate of soda, to a button of pure metallic silver, and redissolve this in pure nitric acid.

Nitrate of silver crystallises in large, flat, nearly transparent, four or six-sided tables. It is soluble in about an equal weight of cold water, and in four times its weight of boiling alcohol, but sparingly soluble in cold alcohol. It is anhydrous, and may be fused and run into moulds. It is slightly deliquescent in moist air. Its solution is perfectly colourless; and neither the crystals nor the solution are affected by light, unless organic matter be present. It is a powerful caustic, in consequence of its ready decomposition by organic matter: it is therefore highly poisonous, salt being the best antidote.

It has been recommended to use fused nitrate of silver in Photography, because all the free nitric acid which it may contain is driven off by the heat in the process of fusion; but this is a bad plan, because nitrite of silver is sometimes formed, which it is found injuriously affects the nitrate bath.

Fused nitrate of silver is generally alkaline, probably because some oxide is formed which is combined with the nitrate. Fresh *distilled* water should always be used for dissolving nitrate of silver, as pump or river water contain salts which produce a cloudy precipitate with it. Rain water collected in leaden tanks should on no account be used, as it contains oxide of lead in solution, which is very likely to fog the negative. Nitrate of silver may easily be fused in a porcelain capsule over a spirit lamp.

Silver, Nitrite of. $Ag\,O, NO_3 = 154$. This salt is obtained by fusing together equal parts of nitrate of potash and nitrate of silver. Oxygen is driven off from the former, which is converted into nitrite, and this again acquires oxygen by converting the nitrate of silver into nitrite. By dissolving the mixture in a small quantity of boiling water the nitrite crystallises out on cooling. The crystals are long slender needles, soluble in 120 parts of water at 60°. This salt is easily decomposed by a strong acid. When present in a nitrate bath it fogs the picture.

Silver, Nitro-bromides, Nitro-iodides, &c., of. These are double silver haloid salts, which form spontaneously in the nitrate bath when it has become saturated with the simple bromide, &c., of silver. Most commonly they are formed in the film itself, when immersed in the bath, and they give rise to many annoyances.

Their exact chemical composition has not been ascertained. Probably they are represented by the formula $Ag\,O, NO_5 + Ag\,B$, or whichever else the haloid salt may be. They all form in crystals of

a needle shape, and are instantly decomposed by water into bromide &c., of silver, and nitrate of silver. They are soluble in large excess of nitrate of silver, and are not decomposed by absolute alcohol, which may be used for washing them for examination.

Silver, Oxide of. There are three oxides of silver, viz.:—

Suboxide	. . . . .	$Ag_2\ O = 224$
Protoxide	. . . . .	$Ag\ O = 116$
Peroxide	. . . . .	$Ag\ O_2 = 124$

Of these the protoxide only forms salts.

Suboxide of silver is produced as a grey film when ammonio-nitrate of silver is exposed to air. It is also produced when citrate of silver (or any analogous organic salt of silver,) is exposed to the action of hydrogen at a temperature of 212°. The protoxide of silver contained in the citrate then loses one half of its oxygen, and the suboxide remains combined with one half of the acid. At least this is Wohler's theory; but the probability is that the acid is also decomposed, and the compound not exactly a subcitrate of silver.

Dr. Graham says, "The solution in water of the suboxide salt is dark brown, and the suboxide is precipitated black from it by potash; when the solution of the subsalt is heated it becomes colourless, and metallic silver appears in it. The salt dissolves of a brown colour in ammonia. Several other salts of silver, containing organic acids, comport themselves in the same way as the citrate when heated in hydrogen."

Protoxide of silver may be obtained by adding a dilute solution of caustic potash to a solution of nitrate of silver. It is thrown down as a dark olive-coloured precipitate.

Protoxide of silver is, like oxide of lead, soluble to a slight extent in pure water, to which it communicates an alkaline reaction. The solution is reddened by exposure to light. This oxide is reduced to pure metal at a dull red heat, and to black suboxide by the action of light. It stains glass of a yellow colour, and is used in painting on glass and enamel. Ammonia dissolves it completely, and forms a colourless solution called ammoniacal oxide of silver.

The peroxide of silver is a curiosity of no value in Photography.

Silver, Sulphate of. $Ag\ O, SO_3 = 156$. Silver may be dissolved in its own weight of boiling sulphuric acid. A white salt is formed which is sulphate of silver. It is also produced by adding sulphate of soda to a solution of nitrate of silver. It is soluble in 90 parts of cold water; and also in ammonia, which forms a double salt, "ammonio-sulphate of silver."

Nitrosulphuric acid formed by dissolving 1 part of nitre in 10 of

sulphuric acid dissolves silver at a temperature below 200°, and the solution may be moderately diluted before sulphate of silver separates from it.

Silver, Sulphide of. Ag S=124. This compound is formed when sulphur and metallic silver are brought in contact. It is also formed by the action of sulphuretted hydrogen on some salts of silver or on silver itself.

It is insoluble in the ordinary solvents of other salts of silver, but soluble in nitric acid, being converted into sulphate and nitrate of silver.

When sulphide of silver is formed in a solution of a silver salt or on silver films, its colour depends upon the quantity present. In mass it is black, when on the surface of photographic prints it is yellow or a dark brown. When it is formed inside the texture of prints it is almost invariably brown and in detached patches.

Sulphide of silver is naturally the most destructive agent to silver photographs. The air always contains more or less of sulphur or sulphuretted hydrogen, both of which have a most powerful affinity for the silver which forms the image. Hence photographs should be protected as much as possible from all atmospheric influences which are likely to act on them.

Silver Meter. *See* "Argentometer."

Silvering of Glass. Several methods have been proposed, and some patents have been taken out for effecting this purpose. As good a plan as any is the following, for which we are indebted to a correspondent of the "British Journal of Photography." Make a solution of ammonio—nitrate of silver, of the strength of three grains to the ounce. Render it very slightly turbid by excess of nitrate of silver, and then filter it. Just before using, add to each ounce of the foregoing solution two and a half grains of Rochelle salt.

Having scrupulously cleaned the glass intended to be silvered, place it in a convenient vessel about one inch from the bottom, supported on three little cones of white wax. The glass plate may be suspended; but in that case there is more difficulty in avoiding vibration, the absence of which is essential to success. Expose to a northern or any other subdued light, and in about two hours the
of silver will be sufficiently thick. It must now be carefully
, washed, and dried.
s prepared in this way may be used in the daguerreotype
for specula and for photographic experiments with pure
f silver.

Sine of an Angle. The size of an angle does not depend upon the length of the lines which contain it, but upon their inclination to one another. This may be measured in a variety of ways. One mode is to find what is called the SINE of the Angle, which is done as follows:—

In either of the straight lines which contain the angle take any point P, and from P draw a perpendicular PN upon the opposite side. Then, if we call the angular point A, the ratio of the perpendicular PN to the hypothenuse AP, of the right angled triangle APN, is the sine of the angle at A.

It matters not where P is taken upon the line AP, for take any other point P′ and draw a perpendicular P′N′ upon the opposite side; then the triangles APN, AP′N′ are similar, and the ratio PN : AP is equal to the ratio P′N′ : AP′.

Since the perpendicular is less than the hypothenuse (except A be a right angle, in which case they are equal), the sine of an angle is a decimal fraction less than unity. It may be found by consulting a table of natural sines.

In old treatises on Trigonometry the sine is generally defined by reference to a circle of which the radius is unity, but that plan is now exploded. In the modern system of mathematics the trigonometrical ratios have nothing to do with a circle. The sine of an angle is not a line, but a ratio, or *number*, and has no linear dimension. If, for instance, a man wants half an orange, he may say, "Give me sine 30° of an orange," the sine of 30° being one half, or ·5.

Sines, Law of. The "law of sines" in Optics connects the angle of refraction with that of incidence, in the case of a ray of light which suffers refraction. *See* "Refraction."

Size. *See* "Gelatine."

Sizing of Paper. *See* "Paper Making."

Soap. *See* "Saponification."

Soda, Acetate of. $NaO, C_4H_3O_3 + 6HO = 136$. Is a salt which is often used in the toning bath with chloride of gold. It crystallises easily, and can be obtained commercially, almost quite pure, at a low price. It is obtained by recrystallising the crude acetate formed during the first stages of the manufacture of acetic acid.

Soda, Bicarbonate of. $NaO, 2CO_2, HO = 84$. The salt called by this name in commerce is often a sesquicarbonate. Both are used to form with citric acid, citrate of soda; and this, to pro-

duce citrate of silver in printing. The bicarbonate is so called, because it contains two atoms of carbonic acid to one of soda.

Soda, Carbonate of. $Na\,O, CO_2 + 10\,aq. = 143$. Manufactured for washing purposes in immense quantities, by the decomposition of common salt by sulphuric acid, subsequent fusion of the product with chalk and coal in a reverberatory furnace, and purification. This mode of making it leaves it adulterated with a small quantity of chloride of sodium and sulphate of soda, but it is generally extremely pure. It is used in the same way as carbonate of potash, and also in making nitrite of soda, for producing nitrite of silver, in removing the size from paper, in separating chloride of copper when chloride of gold is obtained from the standard coin, and in cleaning glass plates.

Soda, Citrate of. $3\,Na\,O, C_{12}\,H_5\,O_{11} + 11\,HO = 357$. This salt may be prepared by neutralising pure citric acid with bicarbonate of soda.

In solutions of silver the crystals yield a white deposit consisting of citrate of silver, which is sensitive to light.

Soda, Hyposulphite of. $Na\,O, S_2\,O_2 + 5\,HO = 124$.

This salt has been used largely in Photography for some years, but its use has had so much to do with the fading of photographs, that it has now become very desirable to find a substitute for it. Its uses in fixing are discussed in the articles treating of the various processes, and we shall therefore, in the present, merely describe its mode of manufacture, and principal properties.

Take of crystallised carbonate of soda 8 parts, rain water 16 parts, sublimed sulphur, 1 part. Mix the ingredients, and pass through the mixture sulphurous acid gas. As soon as this acid is in excess, the liquid contains hyposulphite of soda in solution. Boil it gently for some minutes, filter it, and then evaporate it to one third of its bulk, and place it in a cool place to crystallise. The crystals are four-sided prisms.

Hyposulphite of soda deliquesces in the air. Its taste is bitter and nauseous. When heated it fuses, deflagrates, and takes fire, burning with a yellow flame. It is insoluble in alcohol, which precipitates it from its aqueous solution. It is a ready solvent of the haloid salts of silver, and this, its principal use in Photography, was first suggested by Sir John Herschel. It is neutral to test paper, and extremely soluble in water, with the production of cold. Large quantities of this salt are now made in the neighbourhood of Newcastle-upon-Tyne.

The addition of an acid to a solution of hyposulphite of soda ren-

ders it turbid by causing the liberation of sulphur in a state of fine division.

Soda, Nitrate of. Na O, $NO_5 = 85$. Occurs in a native state in many parts of the world. This impure form is used extensively in the manufacture of nitric acid. In a purer form, which is obtained by recrystallisation, it has been recommended by some in the nitrate bath for sensitising albumenised paper. What its possible advantage there can be it is difficult to comprehend.

Soda, Phosphate of. 2 Na O, HO, $PO_5 + 24$ HO $= 358$. There are several phosphates of soda. The usual phosphate of commerce which is represented by the above formula, and which is the one that is sometimes recommended for use in the gold toning bath, is obtained by acting on bone-ash with sulphuric acid with a slight excess of carbonate of soda. It crystallises on evaporating the solution in fine rhombic prisms, which effloresce. It is soluble in about 4 parts of its weight of cold water, and has an alkaline reaction to test paper.

Sodium, Chloride of. Na Cl. = 58·5. Common salt. A thousand parts of common salt contain from 930 to 990 parts of pure chloride of sodium: chloride of magnesium and sulphate of magnesia are the impurities. If wanted pure for analysis or for testing silver baths, it must be made by exactly saturating pure hydrochloric acid with carbonate of soda, so as to make a perfectly neutral solution: but rock salt is quite pure enough for printing, and other such purposes: if it contains much magnesia it deliquesces. There is a peculiarity in the solubility of this salt, viz., that it is as soluble in cold water as in hot: it requires three parts of water to one of salt. Half an ounce only is taken up by 100 ounces by weight, of alcohol, of sp. gr. 834, so that a very small quantity only could remain in solution in collodion, since it is still less soluble in ether, and that part would be liable to precipitation in the setting of the film.

Sodium, Iodide of. Na I = 357. May be conveniently prepared for experiment (for practical photographic purposes it is useless) by adding iodine to a solution of caustic soda, evaporating to dryness, and fusing the residue.

It decomposes so rapidly when added to collodion, that, although its adoption as an iodizer has been recommended by some authorities, we can only say the experience of the writer is entirely different.

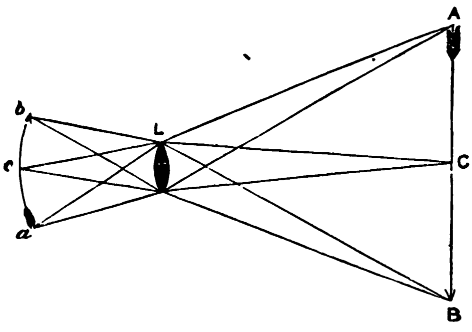
Sodium, Oxides of. There are two oxides of this singular metal, viz., the protoxide and the binoxide. The former with water

is sometimes called the "hydrate of soda" or "caustic soda." Its formula is Na O, HO. It resembles in most of its properties caustic potash; and is white, opaque, brittle, and deliquescent; also very soluble in water and alcohol. Its affinity for acids is rather less than that of potash.

Caustic soda is made from the common carbonate of soda used in washing, by driving off the carbonic acid by heat in contact with quick-lime.

Solar Camera, Woodward's. An instrument used for printing enlarged positives from a small negative, by means of sunshine transmitted through the latter. In order to explain clearly how this optical arrangement acts, we will discuss, in the first place, the theory of obtaining a real image of an object in a camera, and of copying a transparent object having a luminous background.

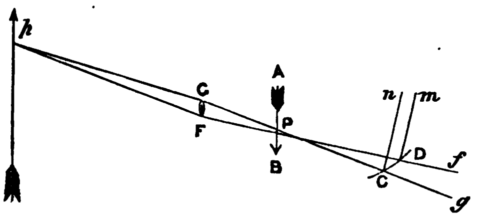
In order to obtain a photographic copy of any object by means of the image of it formed in a camera obscura, the image must be a



"real" one produced according to the law of conjugate foci. Thus, in the annexed figure, if A B is the object, and L a convex lens, a pencil of light, not a single ray, diverges from every point of the object, and after refraction through the lens is brought to a conjugate focus on the other side of it; and the assemblage of these foci constitutes the image of the object. For instance, if A be any point of the object AB, a pencil of light (not a single ray) issues from A, [ent]ers the *whole* of the lens at L, and after passing through it is [brou]ght to a focus at *a*,—A and *a* being conjugate foci; and the [asse]mblage *a c b* of the foci, *a*, *c*, *b*, which are conjugate to A, C, B, [const]itutes the image *a b* of the object A B. Conversely, if *a b* were [the o]bject, A B would be the image of it.

This being understood, it needs no further explanation to show that an image, either reduced or enlarged, can be got of any object from which rays of light actually proceed; that is to say, from any visible object—such, for instance, as a picture, or map, or glass positive, or daguerreotype, which is lighted from the front exactly as the page is upon which these words are printed. That is intelligible enough, and requires no further explanation. But the case is different when we place before a lens a glass negative, the transparent parts of which are clear glass. It is evident that through these portions of clear glass, rays will pass from objects which are situated *behind* the negative; and it is by no means obvious at first sight how an image of such a negative can be produced by the law of conjugate foci just described; because it is difficult to understand how pencils of light can proceed from every point of a clear surface of glass, which cannot in the first instance be illuminated as a piece of paper can.

We will endeavour to explain this difficulty, by reference to the following figure:—



A B is a negative, the lights of which are clear glass, not dimmed by varnish, or fogged by bad manipulation; and F G is a convex lens. Let P be any point within a space of clear glass; and in order to confine our attention strictly to what happens in relation to that point, imagine all the rest of the negative blackened over. In order to copy the negative let there be either the sky, or a large white screen at some distance behind it. Now see what happens. A minute animal placed at F, on the circumference of the lens, could see the sky at *f* through the hole P; and if it were to crawl round to the opposite part of the lens G, it could see the sky at *g* through the hole P; and, in short, at whatever part of the lens F G the supposed little animal were to station itself, it could see the sky between *f* and *g* through the hole P. Hence it follows that certain rays of light from the sky converge towards the point P, and after

passing through it form a pencil which diverges from P, and has its conjugate focus at p, exactly in the same way as if the minute hole in the negative had been a point upon the surface of a white sheet of paper lighted from the front.

What we have proved of the point P is true of any other transparent point of the negative; and is therefore true of any assemblage of such points. But an assemblage of an infinite number of points constitutes an area; and, therefore, we have now shown how any clear transparent space of a glass negative having the sky behind it can have its distinct image thrown upon a screen, by means of a convex lens, according to the law of conjugate foci.

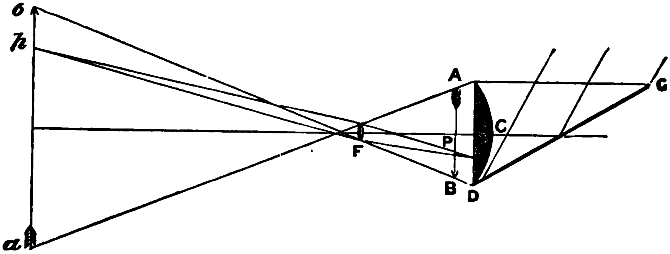
Referring once more to the figure. Suppose C D to be a portion of a reflector of any shape placed behind the negative so as to cut off the sky at $f\ g$ and reflect rays from the sky at $m\ n$. Then since every ray loses a portion of its intensity by being reflected, the converging pencil C P D obtained by reflexion will contain no more rays and will be less intense than the pencil $f\ p\ g$ from the sky direct. It is better, therefore, to have the sky itself behind the negative, than to use a mirror of any shape and reflect light from any other part of the sky. We say a mirror of *any* shape, because a little consideration will show that the curve of the mirror is of no consequence whatever, and makes no difference in the result. It might be supposed that a concave mirror would collect and concentrate the light from the sky upon the negative; but that could do no good, because it would not add to the number or intensity of the rays within the pencil F P G.

It has been supposed that diffraction would interfere with fine focus in copying negatives by transmitted light. But that idea is erroneous. Refer to the second figure in this article. It is true that the pencil F P G may be composed of rays which have suffered diffraction on passing through the hole P, but what does that matter? All we are concerned with is to get a full pencil P F G; and it does not in the least signify what the previous course of the rs may have been.

)bserve also that the pencil F P G may be composed of rays of olours; that does not signify provided the lens F G be achroic, and bring all the coloured rays to a focus at p. P F may a red ray, and P G a violet ray, but that does not matter, because achromatic lens F G brings them both to a focus at p. We shall ve occasion to refer to this statement again presently.

Having now explained the theory of copying a transparent negae with the sky behind, we pass on to a description of Woodward's

This instrument is shown in the next figure. Instead of having the sky behind the negative, there is a large condenser D E, and



sunshine is reflected through it by means of a plane mirror D G. The copying lens is placed at F, the focus of the condenser. Now see what happens. A round image of the sun, about $\frac{1}{4}$-in. diameter, is formed at F, and exactly covers the central part of the copying lens, the outside of which is useless and may be covered with a metal diaphragm to cut off stray rays of light. We shall therefore consider the lens as reduced to $\frac{1}{4}$-in. diameter; and rays of sunshine will then pass from *all* parts of the condenser to *all* parts of the lens. So that if P be a bright point as before, a full pencil of light will pass from P to cover the entire $\frac{1}{4}$-in. disc, or lens, at F; and this pencil will have its conjugate focus at *p*. The same thing will be true of all other bright points of the negative, and thus an enlarged and very brilliant image of it will be formed upon the focusing screen *ab*.

Observe particularly the following features of this arrangement:—In the first place the condenser is not achromatic; and in the next place its focus is brought exactly upon the copying lens. Unless the latter condition be attended to, the enlarged image will be more or less imperfect in brilliancy and definition; and with respect to the condenser not being achromatic, that is of no consequence whatever, because we have before shown that the pencil F P G may consist of rays of *all* colours, and that these will be brought to a focus at *p* if the copying lens is achromatic. If the condenser were achromatised it would be thicker, and light would be lost, while no good whatever would be done as a set off to these disadvantages. The best form of the condenser would be a "crossed" lens, with the most convex side towards the mirror; but it is generally made plano-convex, which is simpler, and answers nearly as well. The form of the condenser should be such as to reduce spherical aberration to a

minimum, and make the image of the sun as sharp as possible, in order that the bases of the pencils F P G may be as small as possible, and the enlarged image as sharp as can be got.

When a portrait lens is used for copying, it must be placed with its back lens next to the negative, and the focal spark of the condenser should be brought upon the centre of the front lens. The distortion produced in this way is scarcely perceptible, but its effect is to bend the marginal lines outwards at their extremities. An achromatic plano-convex lens may be used for copying, and this will give no distortion. It should be only $\frac{1}{4}$-in. aperture, and placed with its flat side towards the negative.

Solarisation. An effect produced by over-exposing to light a sensitive film of iodide of silver. In the daguerreotype process it is seen in the blueness of the over-exposed parts of the picture. A similar effect is exhibited in the over-exposed parts of a collodion positive; and in over-exposed negatives, or collodio-iodised films, developed by pyrogallic acid, it appears as a pale redness instead of a black opacity. The cause of this peculiar behaviour of iodide of silver is at present unknown.

Specific Gravity. The specific gravity of any substance is the weight of a unit of volume of that substance, at a temperature of 60° Fahrenheit.

The unit of volume, in the common table of specific gravities, is the volume of that quantity of pure distilled water which at 60° Fahrenheit weighs 1000 grains; and in the same table the unit of specific gravity is 1000 grains.

The specific gravity of water is therefore 1.

If a vessel containing the unit of volume be filled with absolute alcohol, its increase in weight will be 794 grains, therefore the sp. gr. of absolute alcohol is ·794.

If the same vessel be filled with pure concentrated sulphuric acid, its increase in weight will be 1845 grains, therefore the sp. gr. of sulphuric acid is 1·845; and so on.

Specific Gravity Bottle. This is a small glass bottle shaped like a decanter, and furnished with a stopper which is drilled with a hole, also with a counterpoise, or brass box filled with shot, ... exactly balances it when empty. The specific gravity bottle ...xactly 1000 grains of pure distilled water at 60° Fahrenheit. ...acity is therefore the unit of volume of the specific gravity

To use it, fill it quite full with the fluid to be tested, and put in the stopper. The superfluous fluid overflows through the hole in the stopper. Wipe the bottle quite dry, and weigh it, together with its contents, in a delicate balance, the counterpoise of the empty bottle being placed in the opposite scale. The number of grains required to be added to the scale which contains the counterpoise, and which consequently represent the weight of the fluid, divided by 1000, is its specific gravity.

Specific Heat. By the specific heat of a body is meant the time it takes to cool from a certain given temperature to another given temperature, when placed *in vacuo* in a polished silver vessel. By some writers the specific heat of a body is supposed to be its "capacity for heat," as if heat, which is the undulation of an ethereal medium, could be stowed away among the particles of a body. Surely the notion of "capacity for heat" is absurd. That different bodies should require different times to pass from one temperature to another involves no difficulty of comprehension, and specific heat is simply the measure of the time required.

Dr. Graham says, "Of all liquid or solid bodies water has much the greatest *capacity for heat;* hence the sea, which covers so large a proportion of the globe, is a great *magazine of heat*, and has a beneficial influence in equalising atmospheric temperature. Mercury has a small *specific heat*, so that it is *quickly heated or cooled;* another property which recommends it as a liquid for the thermometer, imparting as it does great sensibility to the instrument."

The reader may amuse himself by trying to state in a different form, and on the assumption of the undulatory theory of heat, the *facts* implied in the above sentence.

The time which a body takes either to become colder or hotter depends in great measure on the condition of its surface. If the surface be smooth, polished, and white, the time is increased; if rough and black, the time is diminished. When an ethereal undulation strikes the surface of a body, it depends upon the condition of the surface whether the undulation be continued among the particles of ether within the body, or whether it be reflected among those which are external to the body; and conversely, when a body is contracting, and therefore radiating heat, it depends upon the condition of its surface, whether the undulations of the ether within the body be communicated to the ether without it, or returned by internal reflexion among the ether within it. A smooth polished surface is favourable to the reflexion of undulations, and unfavourable

to their direct propagation. Colour is no doubt owing to a peculiarity of surface. *See* "Latent Heat."

Spectrum. Suppose a small hole of *any* shape made in the window shutter of a darkened room and that sunshine be admitted through it, and the light received upon a white screen, placed perpendicularly to the line joining it and the hole; then a *round* image of the sun will be formed upon the screen, the diameter of the image depending upon the distance of the screen from the hole. Observe that *whatever* may be the *shape* of the hole, the image of the sun will be *round.* A triangular hole would not give a triangular image, nor a square hole a square image; the sun being round, its image is round; for the image is not produced by a *ray* of sunshine which enters through the hole and falls upon the screen, producing a spot of light the same shape and size as the hole, but by *pencils* of light which diverge from every part of the sun, and after crossing each other in passing through the hole, proceed till they reach the screen, where they form a *round* image of the sun, the size of which increases as the distance of the screen from the hole increases. Thus, the sun being about half a degree in angular diameter, if the screen be placed 10 feet from the hole, the sun's image will be about 1 inch in diameter; if 20 feet from the hole, 2 inches in diameter, and so on.

This being understood, let a glass prism be placed with its edge immediately behind the hole. Then, since white light is not homogeneous, the pencils will all be decomposed by refraction through the prism into pencils of the different coloured lights of which white light is composed; so that the screen, instead of receiving a single round image of the sun in white light, will receive upon a different part of it as many different coloured *round* images of the sun as there are different kinds of light in white light separable by refraction. These images will partly overlap one upon the other, and produce a long image of the sun, having belts across it of different colours, arranged in the following order (if the refracting angle of the prism be suitably taken), viz., red, orange, yellow, green, blue, indigo, violet; which colours are called the "prismatic colours," and the entire coloured image the "prismatic spectrum." Should, however, the refracting angle of the prism be too small, there will be a space of white light in the centre of the spectrum, produced by the coincidence of a portion of each of the coloured images.

The reader will perhaps find this account of the way in which *the prismatic* spectrum is generally produced somewhat different

from the accounts given of it in popular treatises on Optics; these popular explanations generally proceeding on the assumption that the light which is admitted through the hole is a single beam of light,—which is manifestly incorrect. Every photographer knows that an *image* is formed of external objects by light admitted through a small hole in the front of a dark box, and received upon a focusing screen; and that this is true, however small the hole may be and whatever its shape. We have, therefore, to deal with an *image* of the sun, and not with a single ray of white light.

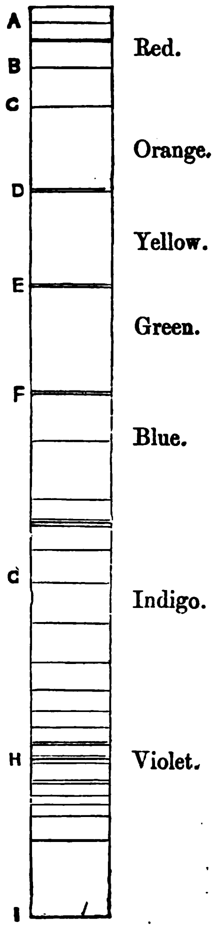
It appears, then, that when the spectrum is formed by admitting the light through a hole, however small, the bands of different colours contain an admixture of lights of different refrangibilities. In order to obviate this evil, M. Fraunhofer admitted the light through a long and extremely fine slit, instead of a hole, and placed the prism with its edge parallel to the slit, *and at a considerable distance from it*. But even this arrangement is not sufficiently exact, for the additional precaution must be taken of covering the prism with an opaque diaphragm, having an extremely fine slit parallel to the edge of the prism, and therefore parallel to the other slit, so that the light from the first slit may also pass through the second slit. In this way the spectrum is rendered nearly pure, and the different parts of it free from the admixture of other colours. And here it is important to observe that in the experiments of Sir David Brewster, in which he detected white light in every part of the prism in a state of admixture with his supposed simple colours, red, blue, and yellow, allowance had not been made by him for the impurity of his spectrum, so that his conclusions that Newton's theory was wrong, and that the seven colours of the spectrum may be reduced to three, was founded on experiments conducted in ignorance apparently of an elementary principle in geometrical optics.

When a pure spectrum is examined by a telescope, it is discovered to be intersected by a great number of dark lines, as shown in the following figure, and which are called "Fraunhofer's Lines," he having first discovered them.

These lines are produced by the absence of light of particular degrees of refrangibility. In the spectra produced by light from different sources the lines do not occur in the same order; neither do they occur at the same relative distances when light from the same source is refracted through prisms made of different materials. In the light from the sun and planets the spectral lines occur in the same order; but in the spectra formed by light from the fixed

stars, or by the electric light, or by light produced by the combustion of different substances, the spectral lines do ***not*** occur in the same order, nor are they equally numerous.

With respect to the calorific, luminous, and actinic properties of different parts of the solar spectrum;—It has been shown in the article on light, that light, heat, and actinism are most probably undulations in the same ethereal medium, differing only in the length of the wave; and it is found by experiment, that both heat, light, and actinism, are capable of producing chemical changes in bodies; so that the term "actinism" merely means that *certain* substances are chemically affected by *certain* rays (called the actinic), residing at a *certain* part of the spectrum.



It is therefore somewhat unscientific to call certain rays "actinic" because they produce chemical changes in certain bodies, and then to say *generally* that the chemical rays chiefly lie at the violet part of the spectrum, when we know that *every* part of the spectrum is capable of producing important chemical changes in some substance or other. To say that the heat rays reside mostly at the red end of the spectrum, luminous rays mostly in the yellow part, and chemical rays mostly in the violet part, is so far unscientific that it is not the statement of a universal law; for the effects exhibited by the different parts of the spectrum upon a substance placed in it, *depend upon the nature of that substance, and are different with different substances.* This being the case, we have not included in the foregoing figure of the spectrum the three wave lines of light, heat, and actinism, with which it is generally adorned in popular works on Photography.

In the following table the lengths of the waves corresponding to the principal lines of the solar spectrum are expressed in millimètres:—

Extreme red	·00075	millimètres.
A	·00074	„
B	·0006879	„
C	·0006559	„
D	·0005888	„
E	·0005265	„
F	·0004856	„
G	·0004296	„
H	·0003963	„
I	·00037	„
Extreme violet	·00036	„

Spectrum Analysis. One of the most important discoveries of modern science, and due to the joint labours of Bunsen and Kirchoff.

The solar spectrum is, as is well known, composed of bands of the different colours, red, orange, yellow, green, blue, indigo, violet, intersected by a vast number of dark lines, which were first discovered by Fraunhofer, and which are due to the absence of light of particular degrees of refrangibility. The solar spectrum invariably exhibits these dark lines in the same order and in the same places. The spectra from the fixed stars exhibit different systems of dark lines. The spectrum from the Drummond light exhibits *no* dark lines. And lastly, the spectra from different coloured flames do not exhibit *dark* lines but *bright* lines, depending in colour and position upon the nature of the substance which gives colour to the flame.

For instance, if a salt of sodium is added to the flame the spectrum consists only of a strong double yellow line, at the part D of the solar spectrum; and the salts of the other alkaline metals added to the flame produce bright lines of different colours in different parts of the spectrum; so that you can ascertain with absolute certainty whether any chemical compound contains any of the above metals by simply examining the spectrum produced by adding some of that compound to the flame which produces the spectrum. Moreover, other metals besides those which form the bases of the alkalies and earths possess similar properties of giving peculiar bright lines in different parts of the spectrum; and the application of these facts in chemical analysis is a new and important branch of that art, and is called SPECTRUM ANALYSIS.

Now follows an important part of this subject. It happens that the *bright* lines given in the spectra from various coloured flames, and which depend in colour and position upon the nature of the

substance added to the flame, are one and all identical in position with the various dark lines of the solar spectrum. For instance, the yellow ***bright*** line, due to a salt of sodium in the flame is identical in position with the ***dark*** line D of the solar spectrum; and so on, in other cases. There is consequently a connection between the ***dark*** lines in the solar spectrum, and the ***bright*** lines in the spectra from various coloured flames. The nature of that connection has at length been ascertained, and the conclusion is one of immense scientific importance. It is this,—that the sun's atmosphere contains the various substances volatilised, and in a state of incandescence, which are present in the terrestrial flames, and give the bright lines which correspond to the dark ones in the solar spectrum. This conclusion depends, however, upon further facts which remain to be stated.

We have said that the Drummond light gives a spectrum which is entirely free from lines. But if a coloured flame containing sodium, or potassium, or any of the other alkaline metals, be interposed between the Drummond light and the prism, the spectrum, instead of showing the ***bright*** lines due to the coloured flame, now shows ***dark*** lines in the same position. This arrangement causes the lines to become dark instead of bright,—or negative instead of positive. The legitimate inference therefore is that the sun consists of a central incandescent solid, the light from which is homogeneous, and would not of itself yield dark lines in the spectrum; but by passing through an incandescent gaseous atmosphere, containing sodium, potassium, iron, nickel, &c., &c., the various dark lines are produced.

Speculum Metal. This is generally a compound of about 6 parts copper, 2 parts tin, 1 part arsenic. It is used for metal reflectors. The great reflector of Lord Rosse's telescope is made of 126·4 parts copper and 58·9 parts tin, without the addition of any arsenic.

The word "Brass" was omitted in the letter B. We may observe in this place, that brass is a compound of copper and zinc, with the addition sometimes of a little lead, tin, and iron. The latter metal should not be introduced in the brass used for philosophical apparatus. The proportions of the metals in brass for turning are as follows:—

Copper	61·6 parts.
Zinc	35·3 „
Lead	2·9 „
Tin	0·2 „

Spermaceti. This substance is sometimes used instead of wax in Photography. It is a soft white crystalline substance, precipitated from the oil of the spermaceti whale on cooling after the death of the animal. It is purified by pressure and boiling in a weak solution of caustic alkali, after which it is washed, melted in boiling water and cast into blocks or cakes. It is soluble in about 50 parts of alcohol sp. gr. ·820. Pure spermaceti is certainly better than impure wax in Photography; and, from its being softer and more easily melted, it penetrates the pores of paper more readily.

Stains. Black stains on the hands, occasioned by nitrate of silver, may be removed by a strong solution of cyanide of potassium and plenty of rubbing; but as this substance is extremely poisonous and apt to act injuriously on the system by absorption through the skin, and more particularly through abrasions thereof, we do not recommend its use. A solution of iodine in iodide of potassium brushed over the stains will convert them into iodide of silver, which is soluble in hyposulphite of soda. Moist hypochlorite of lime rubbed over the stains with pumice stone will also effectually remove them. The most energetic agent of all is a solution of 150 grains of cyanide of potassium, and 12 grains of iodine in one ounce of water.

Stains on linen or cotton may be removed by the second method mentioned above.

Standard Gold. A sovereign weighs 5 dwts. 3·27 grains, and is composed of 11 parts gold to 1 part copper. The standard gold of France contains 9 parts gold to 1 part copper.

Standard Silver. Standard silver consists of 11·10 parts of silver and ·90 parts of copper. A shilling weighs 3 dwts. 15·27 grains.

Standard Spirit. A mixture of alcohol and water, having the sp. gr. ·92 at 62° Fahrenheit. It contains very nearly equal parts of absolute alcohol and water.

Starch. $C_{12} H_{10} O_{10}$ = 12 atoms of carbon and 10 of water. This substance occurs abundantly in vegetables, and is generally obtained by steeping the powdered grain or seed, or the raspings of the root, bulb, or stem in cold water, which becomes white and turbid, and, after being strained, deposits the starch in the form of a white granular substance which is then dried at a gentle heat.

Common starch is manufactured from flour. Arrowroot, tapioca,

and sago are different forms of starch. Starch is frequently made from potatoes.

When starch is heated to a certain temperature, it becomes converted into a gum called "Dextrine" (*q. v.*). It forms a blue compound with iodine, called iodide of starch, an aqueous solution of which is bleached by light; it combines also with sulphuric acid, forming sulphate of starch, and with lime and baryta; also with tannin. Starch becomes converted into sugar by the action of an azotised principle, called "Diastase," and also by the action of dilute acids.

Starch is insoluble in cold water, alcohol, and ether. When boiling water is poured upon it, clots are formed which cannot afterwards be diffused through water. Solution of starch is best made by pounding the starch, and mixing it thoroughly with cold water; then adding hot water, or boiling it, stirring it uniformly until a gelatinous mixture is obtained. A solution of starch is supposed to consist of the granules considerably distended and diffused through the water. When, however, the indurated envelope of the starch granule bursts, the contents are distributed through the water, and form a transparent gelatinous liquid which, on cooling, throws down an opalescent deposit. The substance held in solution in the clear liquid has been called "AMIDINE."

Starch, Iodide of. Iodine combines with starch, and forms a purple compound. Starch is generally used as the test for free iodine. When paper containing starch is immersed in a solution of iodide of potassium it speedily assumes a purple tint, the strength of which depends upon the quantity of starch present in the paper. Also, wherever nuclei of starch exist deep purple spots are produced. Papers which have been bleached with chlorine are also reddened by a solution of iodide of potassium.

Stearine. (Gr. *στεαρ*, suet.) The principal constituent of solid fats. It is composed of stearic acid in combination with glycerine.

Stereomonoscope. This is an instrument invented by M. Claudet for exhibiting upon a screen of ground glass a single picture having the true effect of solidity. This result, which may at first sight appear paradoxical, is accomplished thus:—

A pair of stereoscopic pictures is first taken in the usual way. Magnified images of them are then thrown, by means of a pair of lenses (one for each picture) upon the same part of a large upright screen made of coarsely ground glass, the axes of the lenses converging at a suitable angle. The spectator then stands at a distance

of a few feet on the opposite side of the screen, and looks with both eyes at the image formed upon it. The image formed by the right hand lens is seen by the left eye, and that formed by the left hand lens by the right eye, in consequence of the roughened state of the glass, which is filled with minute transparent spots. A true stereoscopic effect is said to be produced in this way by the combination of the images.

Stereoscope. (Gr. στερεος, solid; σκοπεω, I see.) This is an instrument for exhibiting two perspective views of an object, taken from different stations, as one having the appearance of solidity. It is the invention of Professor Wheatstone, and was first made public and the theory of it explained by him in the year 1839. At that time the pictures were exhibited by means of reflectors, but the inventor suggested that lenses might be used instead. Some years after this, an instrument was brought out by Sir David Brewster, in which small photographic pictures are placed in a dark box, and viewed through half-lenses mounted in tubes; and, soon after the introduction of that very imperfect instrument, Messrs. Knight, of Foster Lane, patented an improved form of stereoscope, in which *large* semi-lenses are used, mounted in the front of the instrument, without tubes; and this, in the course of time, became so generally preferred to the other, as to supersede it to a great extent. But it was soon found that the *semi*-lenses, whether large or small, produced an unbearable amount of distortion in the solid picture, making straight lines look as if they were concave to the spectator; so, in order to obviate this evil, *whole* lenses were tried, and these were found to answer in certain cases. But as the theory of the lenticular stereoscope is even now but little understood by opticians or the public at large, it was not perceived that, in order to render that form of instrument perfect, it was necessary not only to use whole lenses to get rid of the distortion, but to take the pictures in a camera suitably constructed, and mount them properly. We shall endeavour in the present article to explain the theory of the stereoscope in a clear and intelligible manner. But the reader must first consult and study the article on "Binocular Vision," for it is here assumed that the principles of binocular vision are clearly understood.

Theory of the Stereoscope.

The theory of the stereoscope consists in showing, first, how the instrument may be employed to represent things *truthfully* as we see them in nature; secondly, how it may be employed to represent them *falsely* as we *should* see them if our eyes were wider apart,

and, thirdly, to explain how it happens that distortion is introduced by using an instrument of improper construction—straight lines being represented by curves, and so on.

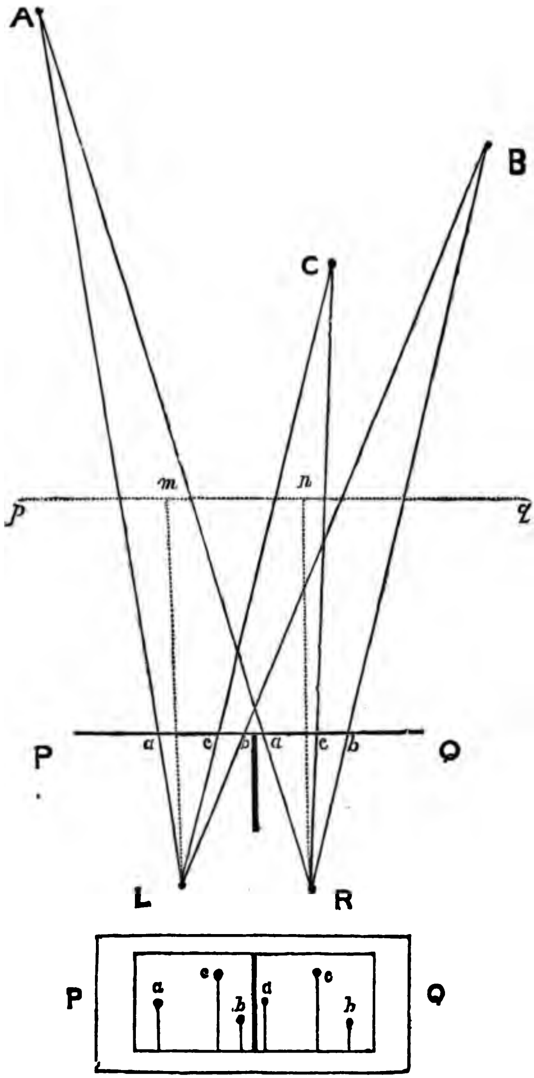
Let L, R be the eyes of the spectator; A, C, B lamp posts of different heights having lights, or luminous points, A, B, C, at the top. Draw the visual rays L A, L C, L B, R A, R C, R B. Cut them by a vertical plane P Q parallel to the line which joins L and R. Then the points *a,c,b, a,c,b,* where the visual rays pass through this plane will be the images of A, B, C, as seen from the stations L and R, P Q being supposed to be the plane of a perspective picture. (*See* "Perspective.") If the plane P Q be placed as shown in the figure, so that the perspective view as seen from L may be completely exterior to that seen from R, the pictures will be as represented on a card beneath L and R. (*See* the Lower Part of the Figure.)

Now if the perpendicular distance between L and the plane P Q be such that the points *a,b,c,* can be distinctly seen by an eye at L, that is to say, if this perpendicular distance be not *too short* for distinct vision, and if we place the card P Q before the eyes, as in the figure, the right picture being cut off from the left eye and the left picture from the right eye by a partition, as shown in the figure, then instead of seeing two pictures *a b c, a b c,* only one image will be seen, and that one image will appear to be the lights A,B,C in their natural position, and at their true distance. For when the left eye is directed to *a* along the line L*a*, the right eye is directed to *a* along the line R*a*, and the optic axes L*a*, R*a*, being produced meet at A, so that the spectator instead of seeing two images *a,a,* upon a plane P Q sees one image A at the true distance, and in the true position of the light A. Similarly with respect to the other images *b,c,b,c,* which combine and produce single images at B and C.

It is evident that the perpendicular distance of P Q from L or R (which we will call F), will depend upon the size of the angle ALB, or ARB; for the smaller that angle is the further the plane P Q may be placed from L and R, and therefore the more easy it will become for the images *a,b,c,* to be seen distinctly by persons of ordinary vision. Most persons can see a thing distinctly at a distance of eight inches. If then $F = 8$, the angle ALB may be about $16°$.

Now we come to the principles of the stereoscope.

Suppose we place at each of the stations L,R, a photographic camera, the lens of which is eight inches focus, and adjusting these *cameras with their axes strictly parallel*, take the pictures of A,B,C,


A
B
C
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(including an angle of 16°). Then when these pictures are properly mounted they will be identical with the perspective views of A,B,C, upon the plane P,Q; and if placed in a box having a partition in the middle, and holes to look through at P and Q *at a distance of eight inches from the pictures*, the spectator on looking through the holes, will perceive a single image of the points A,B,C, at their true distance, and their true relative positions.

A box so constructed may be called a "Simple Stereoscope," because it does not involve the use either of lenses or reflectors, and the pictures properly taken and viewed in it have the inexpressible charm of truthfulness.

Of what use, then, it may be asked, are lenses and reflectors? To this question we will now endeavour to reply.

In the first place the simple stereoscope, when adapted to persons of ordinary sight, does not include an angular field of more than 16°; which is in general too small. A photographic picture should include at least an angular field of from 25° to 30°. This can only be effected by bringing the pictures as near to the eyes as five inches, at which distance most persons find a difficulty in seeing them distinctly; but this difficulty is overcome by placing a *whole* lens of five inches focus in each of the holes L,R, and viewing the pictures (which must be taken with a lens of five inches focus), through them. This instrument is called the "Lenticular Stereoscope." In the following description of it we shall recapitulate what has been said, and discuss the matter more fully.

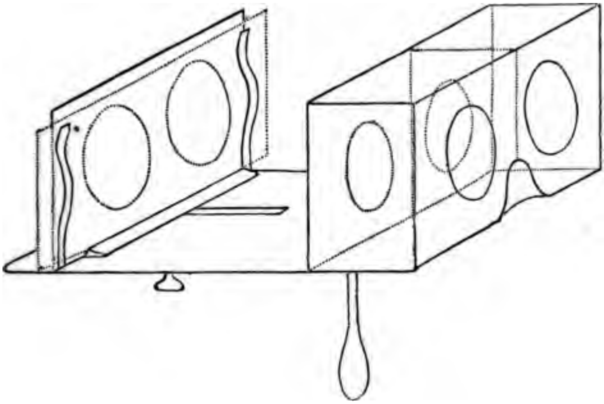
The Lenticular Stereoscope.

This is an instrument for exhibiting a pair of stereoscopic pictures, which include an angular field of about 30°, and have been taken in a stereoscopic camera provided with lenses of five inches equivalent focal length, having their axes parallel, and mounted at a distance L R (=2½ inches) from centre to centre.

A very good form of Lenticular Stereoscope for exhibiting paper pictures is shown in the following figure, which scarcely needs explanation.

The *whole* lenses fixed in the front of the box are placed 2½ inches from centre to centre, and should not be less than 1 inch in diameter. They should be of 5 inches focus, and achromatized meniscus lenses with the hollow side outwards, in fact the same lenses as those used for taking the pictures, which may be unscrewed from the camera, and screwed to the stereoscope. The back of the solid box should have holes in it as represented by the dotted lines, and also a partition in the middle. The holes should be 2¼ inches from centre to

centre, and their diameter determined by trial. If the front box be 2½ inches deep, the back diaphragms should be a trifle more than 1 inch in diameter. A set of diaphragms of different sizes to fit in the



back of the front box would be a useful addition to the instrument. The inside of the front box should be properly blackened. The pictures may be circular, mounted 2½ inches from centre to centre, and about 2¼ inches in diameter. By the centre of each picture is meant the point where the axis of the lens cuts it. In mounting the pictures this is the point to be considered, and no reference whatever is to be made to any of the objects in the pictures. These are always nearer together than 2½ inches, when mounted. The mounted pictures are fastened by springs to a slider which moves in a slit in the bottom of the stereoscope, so that the distance of the pictures from the lenses may be varied to suit different sights, or for trying experiments; the proper distance, however, being 5 inches, which is the focal length of the lenses. The pictures should be mounted upon black cardboard. In order to make the objects appear more distant than the cardboard, that is, in order to make them appear as if viewed through a circular hole nearer to the spectator, the following rule in mounting them should be attended to. Just before trimming the edges, mount them temporarily 2½ inches from centre to centre, upon a piece of cardboard, with pins at the corners; then measure the distance between the nearest object in each picture (this will be less than 2½ inches, probably not much more than 2⅛ inches), and take a dimension a little *less* than this for the diameter of the pictures. With half this diameter as radius, and the

centre of the picture as centre of the circle, strike a circle on each picture, which will be the margin required.

In conclusion, we would observe that the object of taking the lenses as large as an inch in diameter is *not* that the margins of the lenses may be looked through, but simply because when they are too small their circumferences are seen by the eyes, and form two intersecting circles upon the solid picture. Were it not for this circumstance the lenses need not exceed half an inch in diameter.

The stereoscope for exhibiting transparent pictures is of the same general form as Knight's Cosmorama stereoscope, the other points being the same as that of the Stereoscope described above.

It now only remains to explain the exact effect of the lenses upon the pictures. Turning to the figure at the commencement of this article; if a lens of focus F were placed at L, and the eye pressed close to it, a pencil diverging from *b* would after refraction through the centre of the lens be converted into a pencil of parallel rays, without suffering deviation, so that the eye would see the point *b* in the same direction as if no lens were interposed, that is along the line L*b*B, but would have less difficulty in bringing to a focus upon the retina a parallel pencil than one diverging from a point so near as *b*. When, therefore, the eye is placed so close to the lens as to see things exactly through its centre there is no magnification. If, however, the eye be placed at a little distance from the lens it does not look at the side objects exactly through the centre, and therefore the lateral pencils suffer a slight deviation, which increases the apparent angle ALB, and produces magnification, which may, however, be counteracted by putting the pictures a little *further* from the lens than its focal length.

If, then, we leave out of consideration the unavoidable defects of all lenticular optical instruments, it appears that the form of stereoscope that has been described exhibits pictures, *when properly taken*, in such a way as to represent objects precisely as they would appear to unassisted vision, so that natural truth is perfectly realized. And the reader will particularly observe that in this form of stereoscope the images are not displaced or caused to overlap by any optical contrivance. How then, it may be asked, is the effect produced?

Let us examine carefully the pictures upon the card PQ.

In the first place the points *a,a,—b,b,—c,c,* are upon the same rizontal lines, which is simply because the cameras had their axes rallel, and not converging to a point.

In the next place, if we measure the distances *aa*, *bb*, *cc*, we find *s* the *greatest* because A is the *most distant* object; *b b* the *next* cause B is the *next* object in point of distance; and *c c* the *least*

because C is the *nearest* object. But all these distances are less than L R. If, however, in addition to the three lamps, a fixed star D were introduced in any part of the picture, the visual rays L D, R D would be parallel, and the points *d*,*d*, where they cut the pictures would be at the same distance apart as L and R. If then we join L,R, with points *c*,*c*, nearer together than L and R, (and in the same plane with them) the lines L*c* R*c* meet at a finite distance C; but if we join L,R with points *d*,*d*, at the same distance apart as L and R the lines L*d*, R*d* are parallel, or only meet at an infinite distance. Hence it follows that in mounted stereoscopic pictures the furthest objects are the widest apart, and the nearest objects the nearest together; objects at an infinite distance only being as far apart as the distance between the eyes. These considerations will explain at once why it is that there is no necessity for displacing the images of the pictures by half lenses; the objects being sufficiently displaced by the perspective in the pictures themselves, and any further displacement being wrong in principle. The Brewsterian stereoscope, therefore, involves an error of principle.

We have now done with the Lenticular stereoscope. Its defects are those which are inseparable from all optical instruments in which lenses are used, and the pictures are so small that it is impossible to include in them the same amount of detail as in larger pictures. But at the same time for *many* purposes, the smallness of the pictures, involving but a small expenditure of material, and permitting the use of a light and portable form of apparatus in which both pictures may be taken simultaneously, is a real advantage.

We now proceed to an account of the reflecting stereoscope.

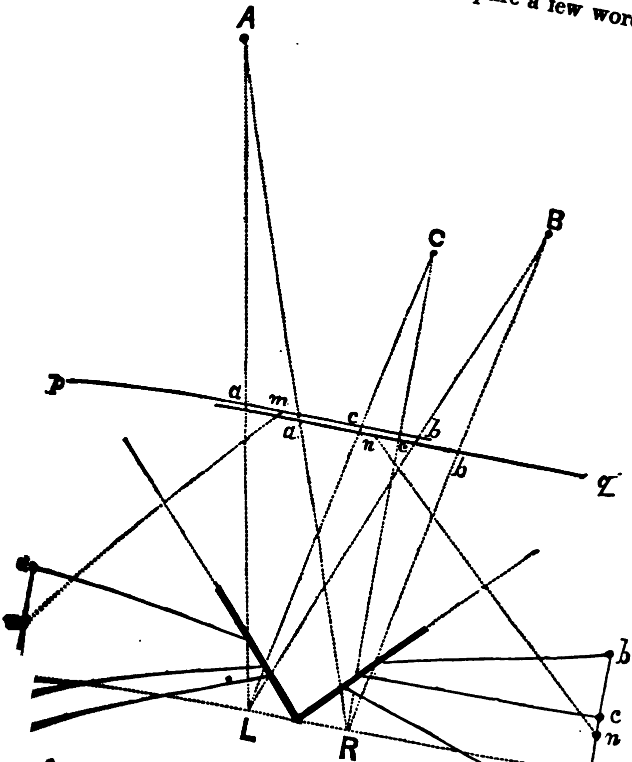
The Reflecting Stereoscope.

Referring to the figure at the commencement of this article. If the visual rays are cut by a plane *pq* instead of PQ the pictures will be larger than before, and instead of being entirely exterior one to the other, will overlap, and be mixed together, so to speak. But if we take the pictures in cameras placed at L and R, with lenses of focal length L*m* or R*n*, having their axes parallel, and then, by means of reflectors throw the virtual images of the pictures so taken into their proper positions on the plane *pq*, and view these images by eyes at L and R, a truthful solid image will be produced, as in the former case; because the left eye will not then see the picture from the right station, nor the right eye that from the left station.

The arrangement is exhibited in the following figure:—

After what has been said on the subject of the lenticular stereo-

scope the following figure will only require a few words of expl
tion.



reflectors are placed at right angles to each other, and the
. at right angles to the dotted line, or base, passing through
gle formed by the reflectors, the distance from that angular
being equal to L*m* or R*n*, and therefore to the focal length of
ns with which the pictures are taken. The distance of the
e points of the pictures (that is the point where the axis of the
viz., *m*, *n*, from the dotted base is half the distance
are taken in a non-reversing slide, so that their
, *pq* as seen in the reflectors, are not reversed;
oint to attend to.

The image of the left hand picture is *pmb;* that of the right hand picture *qna*, the lines *pb*, *qa*, being separated for the sake of distinctness, but in point of fact the images lie on the same plane. The left eye cannot of course see the image of the right picture, and *vice versâ*, so that the images overlapping produce no confusion. The image of each picture and the picture itself are symmetrically situated with respect to the reflector by which it is viewed.

All this being understood, we come to the mode in which the instrument acts.

A pencil from *b* in the left picture, after reflexion at the left mirror enters the left eye *as if* it had come from the point *b* on the line *pb*; the point *b* is therefore seen by the left eye in the direction L*b*. Similarly, a pencil from *b* in the right picture, after reflexion at the right mirror enters the right eye *as if* it had come from the point *b* on the line *qb;* the point *b* is therefore seen by the right eye in the direction R*b*. These two lines R*b*, L*b*, are the instantaneous directions of the optic axes, and being produced they meet at B, which is the true position of the object B. Similarly with respect to the other objects A, C. Therefore by means of the reflecting stereoscope a true representation is afforded in natural relief, and actual distance, of the objects in the picture.

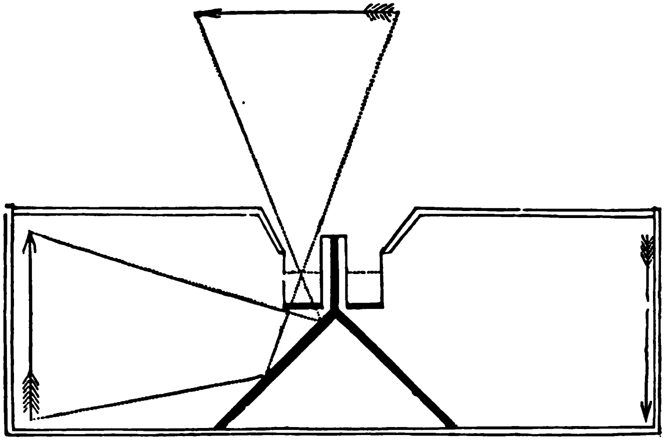
The reflecting stereoscope is not open to any theoretical objection. As an optical instrument it is *absolutely perfect*, being subject to no defects of distortion or aberration. For any scientific purpose, therefore, the reflecting stereoscope should always be preferred to the other. The reflectors may be made of polished speculum metal if objection be raised to glass mirrors, and the pictures may be taken simultaneously in a camera with double lenses 2½ inches from centre to centre, constructed as shown in the following figure, which explains itself.

In this double-reflecting camera the non-reversing slide need not be used.

It now only remains to add a few remarks on taking stereoscopic pictures.

In the first place, the effect of taking the stations wider apart than 2½ inches (the parallelism of the cameras being still preserved) is to bring the near objects in the solid image nearer to the spectator than they were before, and nearer than they are in nature, while the most distant objects remain in their true position. This may be in some cases allowable, because the stereoscope is intended to serve certain educational purposes; and it may happen sometimes that, by giving bolder relief to objects than they really have, the thing to be explained may be rendered more intelligible.

In the next place, the effect of directing the axes of the lenses to the same point at a finite distance introduces distortion in the solid image, unless the pictures are placed in the stereoscope at the same



angle of inclination to one another as the focussing screens of the cameras. When, however, the stations are taken very wide apart (several feet, for instance), if the parallelism of the cameras be preserved, the pictures are partly thrown outside the focussing screen, besides being taken with very oblique pencils; so that, when correct principles of operation are once departed from, for any purpose, other changes in the arrangement of things become necessary. We cannot, however, within the compass of the present work, do more than explain completely the theory of the *correct* form of the instrument; it would require a separate treatise to follow up the subject through all the modifications which it may assume. Enough has been said to enable any intelligent reader to think out the remainder for himself.

In printing stereoscopic pictures from a negative, taken in a double-lens camera, by contact in the pressure frame, it must be borne in mind that the print requires to be cut in half and the pictures transposed, in order to bring the picture that was taken from ation before the left eye in the stereoscope, and *vice versâ.* not attended to, a pseudoscopic effect is produced.

ting stereoscopic transparencies by means of a lens, the plan may be adopted:—

ıg camera, rather more than double the length of the

stereoscopic camera, is provided, and the lenses of the stereoscope are fixed in the middle of it; there must also be a partition dividing the camera in half lengthways. In this way the left lens copies the left picture at the same time that the right lens copies the right picture. The negative must be placed with its back next to the lenses at one end of the box, and the sensitive positive plate in a common slide at the other end. The camera is then directed towards the sky, and the wet collodion process employed. An exposure of a few seconds is sufficient. The positive need not be divided and the pictures transposed, for, when placed in the stereoscope with its plane side next to the lenses, and a ground glass laid against the film, the pictures are in their right position to be viewed. By putting the lenses midway between the negative and positive, the positive becomes of the same size as the negative. The best lenses to employ are doublets, with a small stop between the back and front lenses in each.

In the stereoscopes and stereoscopic pictures commonly sold, there are the following serious defects:—

1st. The pictures are frequently taken in converging cameras, and then mounted upon the same flat surface.

2nd. The pictures are generally mounted so wide apart that the most distant objects in each are wider apart than the distance between the centres of the eyes.

3rd. An attempt is made to obviate the evil produced by the above practice, by using *semi* lenses in the stereoscope, which displace the images. This of necessity produces distortion, because straight lines are always represented by curves when the outside part of a lens is used to view objects through, instead of the centre.

4th. The displacement of the images is in general so great as to cause the optic axes to converge to points situated within two or three feet from the nose, instead of the true distance of the objects. The effect of this is to make the solid picture look like a small model of the object, which the spectator could, if he chose, lay his hand upon, or touch with a yard measure.

Lastly. The focal length of the lenses of the stereoscope is in general six inches, while that of the lenses in the camera is only five inches. This makes objects appear much smaller than they do in nature.

To sum up. The common stereoscope and pictures make objects look very near, very small, and distorted. The stereoscope described and recommended in the present article makes them look of their *true* size, at their *true* distance, and without perceptible *distortion*.

In this article the term "solid image" has been several times used.

The employment of this term may perhaps be thought objectionable; we do not, however, know of a better, and if the thing meant has been clearly understood, the end has been answered.

Stone Blue. A mixture of indigo and starch, moistened with water, made into cakes, and dried. Sometimes Prussian blue is used instead of indigo.

Sulphides. Sulphur combines in various proportions with most of the metallic and non-metallic elements, and forms compounds called "sulphides," or "sulphurets."

Sulpho-cyanides are salts, whose composition only differs from the cyanides in that they contain two equivalents of sulphur. When the alkaline cyanides are fused with sulphur, they readily take to themselves another atom of sulphur, and are converted into sulpho-cyanides. They possess the properties of dissolving certain salts of silver, and for this reason they have been proposed as fixing agents, but their superiority over hypo-sulphite of soda is very doubtful.

Sulphur. S=16. A yellow, crystallised elementary body, found chiefly in the neighbourhood of volcanoes. About 20,000 tons are consumed annually in England, and are imported chiefly from Sicily. It exists abundantly in combination with lead, copper, and iron.

Sulphur is highly combustible, and burns with a blue flame, producing sulphurous acid. It is insoluble in water, and permanent in the air. It fuses at 232°. When heated to over 430° and under 480°, it becomes viscid and of a brown colour; if it be then poured into warm water it becomes soft like wax, and may be used for taking impressions; it becomes hard when cold.

Sulphur is totally insoluble in water and alcohol. Some of the essential and fat oils dissolve it, but the best solvent of all is bisulphide of carbon.

Sulphur Toning. When an argentine photograph having the reddish tint produced by the combination of suboxide of silver with organic matter is placed in water containing a small quantity of sulphide of ammonium, the tint gradually changes from red to purple, and thence to green-yellow. This is called sulphur toning, the yellow substance being supposed to be sulphide of silver in an allo-pic state; or it may possibly be a bisulphide of silver; or a uble sulphide of silver and ammonium. A similar result occurs en the print is placed in a bath of hyposulphite of soda containing stable sulphur salts, or unstable compounds of sulphur and ygen, or free sulphur in a nascent state or state of fine division,

exhibiting a milky turbidity in the bath, produced by the addition of an acid to it.

The ordinary fading of positives appears to be nothing more than the sulphur toning process carried to the yellow stage, in consequence of the presence of a destructive sulphur salt which cannot be removed from the paper. The combination of organic matter with the silver may have something to do with the result, and with the composition of the yellow substance. Photographs of a black tint, produced by development, and containing a much greater quantity of material than sun-prints, and that in a form much more nearly metallic, are found to be more permanent than the latter.

Sulphuric Acid. $SO_3=40$. There are many combinations of sulphur with oxygen, all of them being acids. Sulphuric acid contains the highest proportion of oxygen. It can be obtained pure—that is, without the presence of water—but cannot be kept in the anhydrous state; so that any chemical formula to designate its general constitution does not truly indicate its exact composition.

The method of preparing this acid on a large scale is so instructive in the chemistry of the reactions of elementary bodies brought into atomic contact, that we would fain have embodied the details of the whole process here, but space forbids. In Dr. Miller's "Elements of Chemistry," Vol. II., the whole matter is explained in his usual lucid manner.

In Photography the principal use of sulphuric acid is confined to its employment along with nitric acid, or nitrate of potash in the manufacture of pyroxyline. There are other minor appliances, such as cleaning of glass plates, &c., which we need not here farther refer to. They will be found under their proper headings.

The impurities contained in the commercial sulphuric acid are generally not of such a nature as to interfere with its photographic properties, either in the manufacture of pyroxyline or in the cleaning of glass plates. *Water* is the most dreaded impurity in making pyroxyline, and that can be detected very easily by taking the specific gravity, which should range from 1836 to 1845. Adulterations of dissolved salts to increase the specific gravity of a weak acid would not *pay* the manufacturer, on account of the cheapness of the acid itself. He has, therefore, no object to serve by adulterating it in this way.

Sulphuric acid (hydrated only) possesses most powerful chemical affinities. These, and the impurities often present in it, have little to do with Photography.

Sulphurous Acid. $SO_2=32$. This acid is produced by the

combustion of sulphur in oxygen. At ordinary temperatures it exists as a gas, but at the freezing point becomes liquid. At a lower temperature it may be solidified, and then forms a white mass. Water which has been recently boiled absorbs about 30 volumes of it. The solution possesses bleaching and deoxidising properties.

Talbotype. A negative process so named from the inventor, or Mr. Fox Talbot. *See* "CALOTYPE."

Tangent. The tangent to a curve at any point P is defined thus: Take any other point Q, and draw a straight line through P,Q. This straight line cuts the curve in the points P, Q, and is called a "secant." Now let the point Q move along the curve towards P. When it has approached to within a distance less than any assignable distance from P, but without actually coinciding with P, the secant P,Q. becomes a tangent to the curve at P.

This definition applies equally either to the case of a curve of double curvature (like a corkscrew), or to a curve which lies upon a plane.

The TANGENT-PLANE to a surface at a point P is found by cutting the surface by any two planes which pass through P, finding the tangent lines through P to each of the plane curves thus produced, and drawing a plane through those two tangent lines.

If two points, Q, R, be taken upon the surface, and a plane PQR drawn through them, and we suppose Q, R, to move towards P, then the plane PQR, when Q and R have approached P to within a distance less than any assignable distance, is *not* necessarily the tangent plane at the point P, as it is sometimes stated to be in books of geometry.

Tannin; Tannic Acid. $Tn. = C_{54} H_{22} O_{34} = 618$. An astringent principle contained in various vegetable substances, but principally in infusion of galls. It is obtained in a pure form by treating powdered galls with washed ether, *i.e.*, ether containing 10 per cent. of water; this is allowed to filter through the galls, and the filtered liquid divides itself into two strata, the upper one being ether, and the lower a concentrated aqueous solution of tannic acid. This is evaporated in vacuo over sulphuric acid, and pure tannin remains as a bulky pale-yellow residue, which is exceedingly soluble in water, but less soluble in absolute ether and alcohol.

The aqueous solution of tannic acid reddens litmus paper, and exhibits the properties of an acid, displacing carbonic acid from the carbonated alkalis with effervescence, and forming salts called tannates.

Tannin combines energetically with gelatine, and forms an insoluble precipitate when added to solutions of isinglass, or glue. When oxidised, tannin becomes converted into gallic and carbonic acids. Its chief use in Photography is in the dry collodion processes (*q. v.*).

A concentrated solution of tannin is precipitated by nitric and hydrochloric acids, but not by oxalic, tartaric, lactic, acetic, or citric acids. Tannin, when added in excess, gives a dark blue or black colour to solutions of the *per*salts of iron, but produces no immediate change in solution of the pure *proto*salts. The black precipitate produced in the former case is common writing ink, and is composed of one atom of peroxide of iron and three atoms of tannic acid.

Tannin Process. Photographers are indebted to Major Russell for the discovery of this, perhaps the best of all dry processes. Several modified formulæ have been suggested and worked out by Major Russell himself, and by others; but space will only permit us to describe briefly the two principal modifications upon which all others are based.

1*st Process with Common Bromoiodised Collodion.*—The glass plates should be thoroughly cleaned as usual, and if large, coated with a thin solution of gelatine, or better still, with the "coating fluid," described under that heading. The object of this substratum is to prevent the collodion film from leaving the glass during washing, development, &c. It also serves another purpose, in preventing the sensitive medium from being contaminated with impurities in or on the glass.

Almost any bromoiodised collodion serviceable in the wet process will give good results with tannin. Coat the plate as usual, but allow the film to *set* for rather more than the ordinary time, before immersing it in the nitrate bath, which should be slightly acid, and of the strength of from thirty to forty grains to the ounce. When the plate is fully sensitised, place it for about five minutes in a bath containing distilled water. It should then be transferred into another bath containing common water. Not less than four of these baths containing a large supply of water should be used, and in each of them the plate should remain at least five minutes, in order to withdraw all the free nitrate of silver from the film. It is necessary that the whole of this should be removed or converted into a haloid salt, otherwise the film will become brown when the tannin is applied. A final rinsing with distilled or filtered rain water is useful before applying the tannin.

The plate is now ready to be treated with a solution made in the following proportions:—

Tannin	12 grains.
Distilled water	1 ounce.

Dissolve and filter, then add one drachm of alcohol for each fluid ounce of solution. The addition of alcohol serves two purposes: the first is to enable the liquid to penetrate the collodion film more rapidly, and the second, to prevent decomposition of the tannin solution, should it be deemed desirable to keep it for some weeks or months.

While the plate is still moist from the washing water, a portion of the above tannin liquid is to be poured on and off the plate several times for at least two minutes. The residue of the tannin thus used may be returned through a filter into the stock-bottle and used again. But a surer and better method of applying the solution evenly is by immersing the plate for three or four minutes in a dipping-trough containing the tannin. When taken therefrom, the plate, after being drained for a minute or so, should be stood up to dry in a warm and dark cupboard, on several folds of clean blotting-paper, which absorbs the superfluous drainage-liquid, and prevents it from reflowing over the plate by capillary attraction. When dry, the plates are fit for use, and may then be stowed away in dry plate-boxes, to be used when wanted. Artificial heat should not be used for drying tannin plates, unless great precautions are taken to apply the heat *uniformly* to every portion of the plate.

Plates thus prepared will keep well for many months, perhaps indefinitely, *before* exposure, but not nearly so well in the interval between exposure and development.

The proper time of exposure is dependent on so many circumstances, such as the actinic intensity of the light, the focal length and the aperture of the lens, the mode of development, &c., that it is not possible for any one to lay down even approximate rules. Within our own practical experience the exposure may vary from one second to twenty minutes, with the ordinary bromoiodised collodion treated as above directed, but under different conditions of lighting and development.

Major Russell again we are indebted for the following devel- fluids, which are not only very suitable for the tannin but for ner dry processes:—

(1.)	Pyrogallic acid . . .	96 grains.
	Absolute alcohol . . .	1 fluid ounce.

lter and keep in a well stoppered bottle.

The solution will scarcely become discoloured or deteriorated after six months' keeping. Five minims of it contain one grain of pyrogallic acid.

(2.)	Nitrate of silver . . .	10 grains.
	Citric acid . .	10 to 60 „
	Distilled water . . .	1 ounce.

Dissolve and filter.

The amount of citric acid is left very indefinite. The heat of the weather (which always renders a larger proportion necessary), and the conditions of exposure, affect the question. It would therefore be desirable to take the minimum weight of citric acid in the above formula, for mixing with the nitrate solution, and have another bottle containing:—

Citric acid	20 grains.
Distilled water . . .	1 ounce.

When occasion required, let this be added to the developer, according as to how the action is more or less rapid.

When an exposed plate is about to be developed, if it has been previously coated with an understratum of gelatine, gutta-percha, or india-rubber, no particular care farther than the ordinary share of delicate manipulations required in the wet collodion process are necessary; but, if the plate has not been previously so coated, then it will, in most instances (especially when large plates are used), be absolutely required to run a camel's hair brush, dipped in any of the collodion negative varnishes, all round the edge of the film, to the depth of about ⅛-inch, before development commences, otherwise the developer, &c., may get underneath the film and detach it entirely from the glass. The above precaution is a wise one under any circumstances.

The next step is to moisten the surface of the film with equal parts of alcohol and distilled water; then to wash it for about a minute under a tap, till all tendency to the formation of greasy-looking lines in the direction of the drainage, when the plate is held perpendicularly, has disappeared. When the water appears to flow freely over the surface, mix (for a plate 8 × 5 inches, and for others in proportion) half a drachm of developing solution No. 1, with one and a half ounce of distilled water. Pour this over the plate two or three times, and then add to it two drops of solution No. 2, but this latter must be intimately mixed with the pyrogallic liquid before the compound mixture is applied to the plates. It will now be readily seen whether the picture has been under or over exposed. If, after pouring the developer *on and off the film* several times, nothing but the high lights

appear, then add more pyrogallic acid, and a drop or two of solution of nitrate of silver not containing citric acid. If, on the other hand, the picture bursts out quickly without such addition, then add more acid silver, or still better, a few drops of plain citric acid solution. Thus, by a judicious management of pyrogallic acid, nitrate of silver, and citric acid, the development of a dry tannin plate, no matter what has been the time of exposure, is very much under control.

When the development is finished, the negatives are, of course, fixed and washed as usual. For the fixing, hyposulphite of soda is much preferable to cyanide of potassium, because the latter in many cases weakens the half tones.

Another method of developing tannin plates has also been discovered by Major Russell, whereby the time of exposure is much reduced. *See* "Developer, Alkaline." One formula with bicarbonate of soda is given under the heading referred to, and its mode of application described. Another formula preferred by some is the following:—Dissolve 6 grains of commercial carbonate of ammonia in 2½ ounces of distilled water, and 1½ ounce of alchohol, and keep in a stock-bottle. A drachm or more, according to circumstances, of this is mixed with a plain 2 or 3 grain solution of pyrogallic acid, and applied to the film according to the directions given for the formula with bicarbonate of soda.

Tannin Process with bromised Collodion, or Russell's Process.—Major Russell considers this process at least twice as sensitive as the best common bromoiodised collodion, and eighteen times more sensitive than simply iodised collodion, when each has been treated in the manner that best suits its requirements. The formula for the collodion itself is given under "Collodion, Bromised" *q. v.* All the operations are the same as those already described, excepting that the strength of the nitrate bath should be 60 grains, and the time of immersion 15 minutes. Dry plates carefully prepared by this method, and developed by the alkaline developer, are nearly, if not quite as sensitive as wet ones.

Taupenot Process. This is a collodio-albumen process for obtaining negatives, so called from its inventor Dr. Taupenot. *See* "Collodio-albumen."

Tartaric Acid. Tar. $= C_8 H_4 O_{10} + {}_2HO = 150$. This acid exists free in many acid fruits and plants, and is generally obtained from cream of tartar, in the form of white crystals, which are soluble

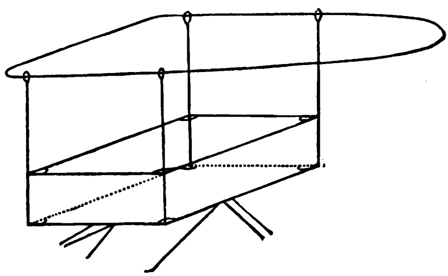
in about 4 parts of water at 60°, and also in alcohol. It is a very powerful organic acid in Photography, and should be used with caution. It is deliquescent in damp air.

Paper washed with a solution of tartaric acid is said to be slightly sensitive to light.

Tent. When views are taken by the wet collodion process, in which the free nitrate of silver is not removed from the plate by washing, it becomes necessary to operate either in a dark room, or van, or tent, at or near the spot whence the view was taken; for otherwise the latent image is destroyed by the evaporation of the moisture from the sensitive plate, and by the consequent solution of the iodide of silver by the concentrated nitrate in the film.

The dark tent used by travelling photographers is of various forms and sizes, and more or less portable. For large pictures 12×10 or so, perhaps the best form is that of the ordinary military tent, having a pole at each end and fastened to the ground with ropes and pegs. It should be made with black calico, lined with yellow. In one of the gable ends there should be a yellow window, and the entrance should be in the opposite gable. Inside there may be a table and all the necessary conveniences. This kind of tent has of course no pretensions to portability, and a travelling van is preferable, since much time is necessarily occupied in erecting and taking down a tent of this form.

For stereoscopic pictures, or pictures not exceeding 8×6, a much simpler and more portable form of tent will answer the purpose. A deal tray about 2ft. 6in. long, 1ft. 9in. wide, and 4 ins. deep is screwed upon a short tripod stand. At the corners the four uprights of a light iron frame are inserted, which is made thus:—



the rods being about the thickness of stair rods.

A covering made of black calico lined with yellow is thrown over

this frame, and hangs down to the knees. In this covering at the back is a yellow window nearly the whole height of the iron rods and about 6 inches wide; the yellow curtain of this window or aperture may be drawn backwards and forwards at pleasure. The tray has a shelf at the back which carries the bottles, etc.

To use this tent the operator stands beneath the projecting part of the top of it, with the tray in front of him, and draws the lower part of the curtains tightly round him under his elbows, and fastens them by means of hooks to the inside of the front part of the tray, so as to exclude day-light. He has then his hands at liberty, and manipulates in the usual way. By putting a tent of this kind, together with the chemicals and apparatus, upon a wheelbarrow, or suitable truck, or basket with wheels which ship and unship, the photographic tourist becomes independent of help from others.

Test Papers. Make an infusion of commercial litmus, and steep blotting paper in it; dry it, and cut it into narrow strips. It is of a deep indigo colour, and is reddened by being immersed in any acid solution, or exposed to acid fumes. This blue litmus paper, as it is called, is therefore a test for acidity. It may also be used as a test for alkalies by dipping it into very dilute sulphuric acid, and drying it. In this state it is reddened litmus paper, and its original blue colour is restored by immersion in any alkaline solution. A volatile acid, such as acetic, should not be used in making reddened litmus paper. Another kind of test-paper for testing alkalinity is made by steeping blotting paper in an infusion of turmeric; this is of a yellow colour, which is changed to brown by the action of an alkali. It is not considered so good as reddened litmus. But the best kind of test paper for testing alkalinity is made by steeping blotting paper in a strong infusion of the petals of the red rose. The red colour of this kind of paper is changed to green by an alkali.

When a solution to be tested is very *feebly* acid or alkaline a few minutes must be allowed before the change of colour in the test-paper is perceived.

Test-papers, as usually sold by chemists, are made up in little long narrow books. They are indispensable to the photographer for testing the condition of the nitrate bath.

Tetrathionic Acid. $S_4 O_5 = 104$. This substance is one of many oxides of sulphur described by Berzelius. It is formed n iodine is added to hyposulphite of soda. A clear solution re-s, which contains iodide of sodium, and a salt of this peculiar

It was at one time common to tone photographic prints in a solution prepared as above, but as the colouration of the proofs was due to sulphur, the process has been very properly abandoned.

Thermometer. (Gr. θερμη heat, μετρον a measure). This is an instrument for measuring temperature by recording the expansion produced in a liquid by heat.

The mercurial thermometer consists of a glass tube of fine and *equal* bore, having a bulb at one end. This tube is filled with mercury at a high temperature, above boiling point, and its end hermetically sealed. On cooling, the mercury contracts and leaves what is called a Torricellian vacuum above it in the tube, *i. e.*, a space filled with the vapour of mercury.

To graduate the thermometer, it is first immersed in melting snow, the temperature of which is found to be invariable, and the height of the mercury marked; and next in water boiling in a thin polished metallic vessel at a barometric pressure of 30 inches, a temperature which is also found to be invariable, and the height of the mercury marked again. These two graduations are called the freezing and boiling points of water. The space between them is divided differently in different thermometers, as shown in the table at the end.

The thermometer used for testing the temperature of liquids is furnished with a hinged back, so that the bulb and lower part of the tube only can be inserted in the liquid.

If equal parts of hot and cold water are mixed together the thermometer indicates accurately the arithmetical mean between the temperatures.

Tincture of Iodine. This is composed of 48 grains of iodine added to one fluid oz. of alcohol sp. gr. 835. The iodine is dissolved and the tincture poured off into a well stoppered bottle.

Tints, Photographic. Solutions of various colours, in which positive prints are immersed, after being washed and fixed, in order to dye the paper an agreeable tone, and destroy the unpleasant whiteness of the lights of the photograph. They are manufactured and sold, in a concentrated state, by Messrs. Bailey, of Wolverhampton. Very great dilution is necessary before use.

Toning-Bath. In printing positives by direct light, the purple tint due to the subchloride of silver is removed by the fixing agent, and nothing remains but a red compound of silver and organic matter. In order, therefore, to render a sun-print presentable as a work of art the thin red tint of the shadows must be blackened or

intensified by some means. This is effected by the toning bath, which either darkens the print by sulphuretting the silver in the image (*See* "Sulphur Toning"), or by substituting gold for silver, according to its composition. (*See* "Printing," &c. Developed prints do not necessarily require a toning bath, since the material of the image is sufficiently black and intense without it.

Tracing-Paper. There are two kinds of tracing-paper, viz., transparent and black. Transparent tracing-paper is made by smearing the paper with boiled oil, or magilp, or colourless dammar resin dissolved in turpentine or benzole; or, better still, with Canada balsam diluted with turpentine. Black tracing-paper is made by saturating a piece of blotting paper with a mixture of lamp-black ground in honey, or by rubbing a piece of sized paper with black-lead or black chalk. The tracing is first made upon the transparent paper in lead pencil, this is then laid upon the black paper, and that with its blackened side upon the paper which is to receive the final drawing. The lines on the tracing-paper are then gone over with a porcupine's quill, or other hard point, exerting a gentle pressure. A corresponding outline is thus obtained upon the paper beneath the black one. Sometimes blue paper is used instead of black; this is made by substituting indigo or prussian blue for lampblack.

The transparent paper made with Canada balsam takes ink and water colours freely. A tracing-paper is made in France from raw flax, and is called "Papier Végétale."

Transferring. A collodion picture which is not too porous and powdery may be transferred from the glass plate, when wet after the final washing, in the following manner:—

Lay a thick and wet piece of blotting paper upon the film in such a way as to cover the plate all but about a quarter of an inch at one end. Turn the narrow edging of film which is outside the blotting-paper over it by means of a penknife, and then, beginning at that end, raise the blotting-paper gently off the plate; the film will come off with it. It may be permanently fixed to a sheet of dry gelatinised paper, by laying the blotting-paper bearing the film upon the gelatinised paper, pressing the two into close contact, and ing them dry spontaneously, when the blotting-paper will come leaving the film attached to the gelatinised paper so strongly as esist all attempts to remove it again by scratching or rubbing. paper may then be waxed.

Collodion positives may be transferred from glass to glazed her [illegible] both the film and the leather with alcohol, press-

ing the two into contact, and in a few minutes peeling off the leather, which brings the film with it, apparently so incorporated with the black glaze as to be incapable of being removed by scratching with the nail, &c.

Collodion negatives may be transferred to gutta-percha in the following manner, described by M. Leon Cassagne at a meeting of the French Photographic Society on June 19, 1857.

"It is generally known that at the Imperial Printing Office of Vienna, when a good collodion negative has been obtained on glass, it is the custom to transfer it by means of a double film of gelatine and gutta-percha dissolved in chloroform. The process which I have adopted, and which has never been described in the Bulletin of the Society, consists in first dissolving—

Pure gutta-percha . . .	1·92 grammes
Chloroform, or benzole . . .	31·09 „
or,	
Gutta-percha	2·56 grammes
Chloroform, or benzole . . .	31·10 „

"You perceive that the quantities are not invariable. There are cases in which it is necessary to vary them. I shall not enter into details; the operator, in each particular case, will be able to decide for himself.

"When the negative on the glass is dry and in good condition, pour on the collodion side a coating of the above solution. Let it run slowly and uniformly, that it may have time to penetrate and unite with the collodion film. As soon as this coating is completely dry, strengthen it with a second, formed of the following substances:—

Gelatine of commerce (very white) .	30 grammes
Filtered water, as much as the gelatine can absorb, until it has swelled to the utmost.	
Isinglass	5 „
Alcohol	15 „

"Melt the gelatine in the water which it has absorbed, by placing the vessel containing it in hot water. Melt the isinglass in the same way in the alcohol. Mix by degrees, and with care; stirring with a wooden spatula this species of varnish. Warm it with precaution, that it may not be injured by too much heat. Hold the negative, the coating of gutta-percha upwards, before a clear fire, or over a spirit lamp, until it is heated to 10 or 20° centigrade; then pour over it immediately (removing it from the flame of the

lamp), a coating of gelatine, as thin as its density will allow. It is unnecessary to say that the gelatine must be warm and perfectly liquid at the time. Leave it for an instant to cool and dry, sheltered from dust, and you will be able to remove easily, by means of the steam from boiling water, the triple film of collodion, gutta-percha, and gelatine. This operation, which is very easy, is performed as soon as you see that the film is slightly softened by the steam and you should then begin to remove it from the glass at the corner from which the excess of collodion was poured off when the plate was collodionised. It often happens that the film disengages itself at this corner of the glass. It is a good plan to facilitate the entire removal of the film with a thin blade of flexible polished horn, on which, with the help of fingers, you support the film, while you detach it by degrees, either with, or without, the aid of a thin thread of water, running drop by drop from a tap, and which insinuates itself by degrees under the collodion, between it and the glass. As soon as the entire film is raised, flatten it between two pieces of glass, having good surfaces, and sufficiently thick to act by their own weight. The collodion used must have *sufficient* consistency, not so much, however, as to leave striæ or lines on the plate when dry.

"The chloroform or benzole solution should be allowed to stand several days before being used, in order that the colouring matter, or any impurities in it, may be deposited. Filter through paper, that the solution may be sufficiently thin, shutting the top of the funnel to prevent too much evaporation, which would have the effect of thickening the solution. Benzole, of specific gravity much less than the chloroform, gives good results, but inferior to those obtained by chloroform, which gives a solution almost colourless, and adheres firmly when the evaporation is completed; which also takes place more rapidly than with the benzole.

"The density of the solution of gutta-percha, which is always slightly coloured, retards considerably its complete clarification. It is necessary to avoid all impurities in this solution."

The following is a method of transferring dry collodion negatives to paper, described by M. Bayard at the meeting of the French Photographic Society on Feb. 20th, 1857.

"Among the specimens which I have the honour to lay before you are some which have been obtained from very old negatives, and n from negatives which have been varnished. They have all 1 easily transferred. I cannot however promise you that it will ys be so. It is probable that certain varnishes, and particularly varnishes, may offer an impediment to the softening and removal e collodion film.

"I am afraid also that albumen and gelatine spread upon the negatives may interfere with the success of the operation; and I must warn you that I have not yet succeeded in transferring with certainty negatives produced by Taupenot's process, either simple or modified.

"The following is my process:—

"In order to detach the film of collodion from the glass, I use paper coated with gelatine.

"To prepare it, dissolve in one *litre* of filtered rain water, 40 *grammes* (about 4 per cent.) of colourless gelatine. When the gelatine is dissolved, pour the solution into a dish which has been previously heated. Float the papers on the bath for one or two minutes, and hang them up by a corner to dry. When dry, keep them in a portfolio until required for use. The kind of paper which appears most suitable for this operation is Canson's thin negative paper.

"If the negative to be transferred has just been taken, and is still wet, place the glass on a horizontal support, collodion side upwards, and cover it equally and evenly with water. Then, take a sheet of the prepared paper, (which should be of the same size as the glass,) float the gelatinised side for three or four minutes on a bath of water, and having carefully removed it, lay it on the water with which the glass has been covered. Then, by inclining the glass, allow the water to drain off and the paper to become attached to the collodion. Place the glass perpendicularly, and allow it to dry spontaneously.

"When the negative which you wish to transfer is old, and has not been varnished, immerse it for about a quarter of an hour, film upwards, in a dish full of water. Ten or twelve minutes after putting it into water, lay a sheet of gelatinised paper on the same water for three or four minutes. Then remove the glass by the corners in such a way as to remove with it the paper which floats above, (the edges being of course properly adjusted to those of the glass). By proceeding cautiously the paper will adhere to the collodion. Drain and dry as before.

"When the negative has been varnished, proceed as before, with this difference, viz.:—add 3 or 4 per cent. of alcohol to the water, and let the glass remain in it half an hour.

"When the paper which has been glued to the collodion has become perfectly dry, (it should not be dried by the fire,) make an incision with the point of a penknife all round it, pretty close to the edges of the glass, and then immerse the negative in a dish filled to about an inch deep with water. A quarter of an hour after,

you may endeavour to raise a corner of the negative film with the point of a knife. Should the film not come off with the paper, leave it immersed a little time longer. As soon as you find that the collodion will leave the glass, raise the paper carefully, without removing the glass from the water, which always moistening the collodion renders the operation more easy. When the paper has been removed with the collodion film adhering to it, press it between blotting paper, and dry it.

"Negatives transferred in this way acquire great vigour for printing, and if the prints from them are found to be too strong in the contrasts, the negative should be waxed on the reverse side of the paper in the ordinary way."

After M. Bayard had made the above communication, he, in order to show with what ease these transfers could be made, placed in water a collodion negative on glass, having a sheet of gelatinised paper adhering to the film.

M. Le Gray, who had lent this negative, said that he had warned M. Bayard that it was in very bad condition for transferring, as the film wanted consistency; but that, if the experiment succeeded, it would be the more conclusive. Notwithstanding these unfavourable conditions M. Bayard effected the transfer with complete success.

Collodion positives may be transferred to paper by the following process, communicated to the "Photographic Notes" by Mr. Manson, of Edinburgh:—

"To make the transfer varnish:—Take of borax, 1 dram, shellac, 4 drams; digest them in about 5 ounces of water, nearly boiling, in a covered vessel, till the whole is dissolved; when cold it is ready for use.

"To transfer the film:—Apply a coat of the varnish to the surface of the picture with a large and soft camel's hair brush, and dry it quickly by holding it over a flame, or at a fire; when cold, applying a second coating of varnish as before.

"Then take a piece of black paper a little larger than the glass. Coat it, and also the picture, with varnish, and lay the two wet surfaces together, beginning at one end, and carefully excluding every bubble of air. When nearly dry lift one end, and strip the whole from the glass. It is now ready for mounting."

Daguerreotypes may be transferred to paper by the following process, described by Mr. Belfield Lefevre, of Exeter, in the "Photographic Notes," Vol. 2, page 343:—

"To obtain a negative by transferring to the surface of some

more or less transparent substance the loose particles which form the lights and half-tints of Daguerre's image, is an idea which must have suggested itself to the minds of many, whilst the means by which this transfer may be effected are as simple as the idea itself is obvious; and yet, although from the day on which M. Arago communicated M. Daguerre's process to the Academy of Sciences, I have been a votary of the photographic art, and am not unfamiliar with photographic literature, I have seen no allusion, however remote, to any such process. Is it that the results so obtained have not been found available for the purposes of photographic printing? However this may be, as it is not in my power to pursue these researches any further, I submit the process to your judgment in its present imperfect state, and my sincere desire to contribute to the progress of Photography must be my excuse. The following, then, is a short, but I believe sufficient description, of the *modus operandi*. I purposely omit mentioning those precautions which are familiar to all careful operators.

"1st.—Dissolve one part of pure gelatine, and one part of clarified uncrystallisable sugar (golden syrup of the grocers) in ten parts of boiling water, and pour out the hot solution in a shallow pan.

"2nd.—Float for a few minutes on the hot solution a sheet of Hollingworth's thin negative paper, previously well dried.

"3rd.—Draw off the paper, holding it vertically, at a short distance from the fire, until the superabundant liquid has ceased to drain off.

"4th.—Lay it out horizontally on a cold slab, until the gelatine has firmly set.

"5th.—Meanwhile, take the image to be transferred fresh from the mercury box, and having washed it first in the solution of hyposulphite, and then in water, put it on end to drain, until the formation of the horizontal water line marks that the liquid on the surface is reduced to a mere film.

"6th.—Lay the gelatine paper on the image, pressing it down firmly and evenly with a soft cloth, until it is brought at every point in perfect contact with the surface of the metal.

"7th.—After a few minutes peel off the paper. Some caution will be required, as it will be found to adhere rather firmly.

"If the proof has been well selected, and the manipulation successful, every particle of reduced silver will be found transferred to the surface of the gelatine, and a faint vestige of the original image will alone be traced on the black and polished surface of the silver.

"I say, if the proof has been well selected, for this is a point of much importance. Of course the choice would fall on a full-bodied

proof, with thick and creamy lights, and rich opaque middle tints; but this alone will not be found a sufficient guide, and it will be advisable to pass a camel's hair brush gently over some portion of the washed image; if the passing brush leaves a tract of black and burnished metal behind, the transfer may be attempted, if not, the operation will not be successful.

"On examining the transferred image by reflected light, it will appear as a faint and somewhat shadowy transcript of the original drawing, in which a careful inspection in a favourable light will detect many details reproduced with great sharpness and delicacy. By transmitted light, however, the semi-transparent nature of metallic films of extreme tenuity will be found painfully evident. It is indeed a faint negative, but it differs from those obtained by ordinary processes in two most important particulars. In the first place, its lights are perfectly and absolutely pure, and in the second, its half-tints, however faint, are all represented by a metallic equivalent, really and substantially existing on the surface of the gelatine, and which, therefore, may become the basis of a chemical action, although too minute to be detected by the most careful inspection. The colour of the metallic film varies greatly, generally approaching to a reddish brown where it is most dense. This clearly points out a fact for which we should have hardly been prepared, viz., that the high lights in Daguerre's image are in reality formed of two distinct layers, the upper stratum being blanched by the action of the mercury, and probably amalgamated with it, whilst the lower retains the reddish hue which reduced silver sometimes assumes. The rosy tint which is observable in the high lights of the finest proofs, when seen obliquely, is thus explained. Considered as a basis of chemical action, the transferred image is a sheet of gelatine, on which particles of pure metallic silver, or of silver amalgam, are more or less densely strewn. To increase the opacity of these particles, so as to render them less permeable to the rays of transmitted light, is the problem still to be solved, and for the solution of which three methods are open:—First, to transform the metallic particles into some binary compound, such as an oxide, a sulphuret, an iodide, or a chloride; secondly, to substitute for them thin chemical equivalents of platinum or gold; and, thirdly, to render them the centre of a catalytic action, which shall group around them fresh molecules of reduced silver. The very few experiments which I have been able to make in these different directions have impressed me with the belief that no very serious obstacle is to be apprehended. Thus I have found that the action of iodine transforms the metallic film into a saffron-coloured compound which is not altered by exposure to

light. Bi-chloride of mercury changes it into a greyish powder, which is again darkened by a weak solution of ammonia, and the terchloride of gold increases considerably the intensity of the image, but forms unfortunately, with the gelatine, a compound of a truly Tyrean purple tint.

"All these, however, are topics on which I need not dwell, as they will naturally suggest themselves to the minds of those who may deem the subject worthy of investigation."

Transparent Cement. Dissolve 75 parts of caoutchouc in 60 parts of chloroform, and add 15 parts of mastic.

Transparent Positives may be either taken on glass in the camera, by means of the ordinary wet or dry collodion or albumen processes, or they may be printed on dry plates exposed to light, in contact with a negative. In all cases a negative is necessary. To those who are adepts in the usual negative processes, no special instructions for taking transparencies are necessary. The prints, if not of the desired depth of colour, may be toned after fixing and washing, by pouring on and off a slightly alkaline solution of chloride of gold and again washed.

Treacle. The uncrystallisable sugar or syrup obtained from the sugar cane. Golden syrup is a thin light-coloured treacle, better adapted for photographic purposes than common treacle.

Triplet. *See* "Lens."

Tripoli. The waxen veins, or *Spectoriæ ludi Helmonti*, found on the east coast of England, calcined; also the curl-stone of the Staffordshire mines, calcined. It contains 80 per cent. of silica, and is used for cleaning and polishing metals, &c.

Turmeric. The root of an Indian plant, the *Curcuma longa.* The powder is orange yellow, and the tincture used for making test-papers (*q. v.*) The colouring matter of turmeric is called "curcumine."

Turpentine. Crude turpentine is a kind of balsam composed of a resin and a volatile oil, and obtained as an exudation from the wounded bark of various trees, but particularly the fir. It is imported chiefly from America.

Oil of turpentine is obtained by distilling crude turpentine with water; the residue left in the still is common resin, and the volatile oil passes over with the steam, with which it mixes. It is a limpid, colourless liquid, sp. gr. ·86, and boiling point 314°. It is neutral to test-paper, and almost insoluble in water, but is taken up to a

greater extent by absolute alcohol and ether. It mixes readily with oils, and is very inflammable, depositing a dense soot, which is lamp black, or carbon in a finely divided state. Its composition is $C_{10}H_{8}$. It is a solvent of the resins, and to some extent of caoutchouc.

Oil of turpentine is acted on energetically by sulphuric and nitric acids, and chlorine; with hydrochloric acid it forms a curious compound, called artificial camphor. It combines with iodine and bromine.

Ultramarine. A magnificent blue pigment obtained from a rare mineral, called "Lapis lazuli."

Ultramarine, Artificial. This substance, which is chiefly composed of sulphide of sodium, is extensively used in the arts, particularly by paper makers for giving a blue tint to paper. There is a very large manufactory of it at Dusseldorf, where some hundreds of men and women are employed. The following is the account of the process, as described by Dr. Redwood.

"Mix together 1 part of porcelain clay, 1½ part of sulphur, 1 part of anhydrous carbonate of soda, and keep the mixture at a dull red heat in a covered crucible as long as vapours are given off. On opening the crucible it will be found to contain a spongy mass, part of which will be of a dark-blue colour, and this is to be separated from the other part. The results of this process are not uniform, yet it is considered the best that has yet been published."

Since photographic prints are readily destroyed by an alkaline sulphide, it is evident that the above colouring matter should on no account be added to photographic papers, and yet many of the foreign papers manufactured for Photography are tinted with it.

Uranium. U = 60. This metal is obtained from the mineral termed Pechblende, which is an impure oxide of it, and also from uranitic mica. The process consists in acting on the oxide with potassium. It is obtained as a black powder which has a powerful affinity for oxygen. The protoxide of uranium was for some time mistaken for the metal itself, and is not by any means a costly substance.

There are five oxides of uranium, viz.:—

Suboxide	$U_4 O_3$
Protoxide	$U O$
Black oxide	$U_4 O_5$
Green oxide	$U_3 O_4$
Peroxide / Sesquioxide / Uranic acid	$U_2 O_3$

The protoxide is a grey or brown powder obtained by passing hydrogen over peroxalate of uranium at a red heat. The salts of the peroxide are reduced to salts of the protoxide by the action of light, as in the case of the iron persalts, so that in this respect uranium and iron are analogous. The hydrated peroxide is a yellow powder.

Uranium, Oxide of. $U_2 O_3, NO_5 + 6 HO = 252$. This salt is obtained by dissolving sesquioxide of uranium in nitric acid. It is purified from copper, lead, &c., by passing through the solution a current of sulphuretted hydrogen, which precipitates these metals, but not uranium. The crystals are of a greenish yellow colour, and are soluble in water, alcohol, and ether.

For the so-called Wothlytype process, the nitrate of uranium is purified as follows. To an aqueous solution of it, ammonia is added as long as any precipitate is produced. The precipitate is carefully washed and dissolved in nitric acid, care being taken that the precipitate be in excess, in order that the acid be completely neutralised. The solution is then crystallised.

Uranium Glass. Glass is frequently coloured yellow by the addition of oxide of uranium. It possesses the property of "Fluorescence," *q.v.*

Uranium Printing Process. To Mr. Burnett, of Edinburgh, we are indebted for the discovery of this process. A sheet of paper is first rendered sensitive to light by immersing it in a strong solution of a salt of the peroxide of uranium (the nitrate is probably the best). It is then dried, and exposed under a negative to direct light for about the same time as an ordinary sun-print upon a chloride of silver paper. A very faint visible image is thus obtained, which is perceived by holding the paper against the light. The print is then placed either in a weak solution of chloride of gold, or in a strong solution of aceto-nitrate of silver. In the former case a picture is obtained of a purple inky tint, and in the latter case of a chocolate brown tint. The print is then washed in abundance of water, several times renewed, and the operation is complete.

The theory of the process appears to be as follows:—

The uranium persalt is reduced by light to a protosalt, which, when the print is placed in the gold or silver developer, becomes again oxidised, and the gold or silver reduced, either to a purple substance in the case of gold, or a brown substance in the case of silver. The redundant chemicals are then removed by washing.

The principal objection to this process appears to be the difficulty of obtaining good surface vigour, and fine definition; there is also

the fear of the lights becoming discoloured in consequence of the imperfect removal of the chemicals from the paper.

Uranium prints developed with silver may be intensified by immersing them in a solution of protosulphate of iron acidified with acetic acid; but the lights of the picture are very liable to become discoloured if no fixing agent, such as hypo or cyanide, be employed.

The uranium printing process is identical in principle with the Chrysotype process of Sir John Herschel, published in 1842; *q. v.*

The above is the principle of what is now generally denominated the *Wothlytype* process, patented by Herr Wothly, of Aix-la-Chapelle. The improvements which he has introduced consist in having found out means to preserve the picture on the surface of the paper, and in associating the nitrate of silver or chloride of gold to be reduced with the uranium salt.

Ordinary photographic paper receives a supplementary sizing of arrowroot starch; it is then coated by attaching it to a flat board, with collodion prepared as follows:—

Plain collodion	4 ounces
Castor oil	4 drops
Canada balsam	2 drops
Ammonio-nitrate of uranium . . .	160 grains
Powdered nitrate of silver	6 grains

There have been devised many useless complications for preparing the sensitive collodion. The above preparation is as good as any that we have met with.

The mixture must be shaken up till the whole of the salts are dissolved, when it is fit for use. Being sensitive to light it must, of course, be kept in a dark place, so also must the paper coated with it until it is required for use.

The prints are obtained by pressure in contact with the negative and exposed to light, as in the ordinary printing process, and the progress can be watched just the same, because the developer is here conjoined with the salt to be reduced. The proofs can be toned in alkaline chloride of gold as usual.

It has been supposed that no fixing farther than washing in plenty of water, to remove the uranium and soluble silver salts, is necessary for such prints. This is a mistake. Some of the nitrate of silver has entered into combination with the organic and other salts in the collodion and paper. Hence treatment with some one of the usual fixing agents is necessary, and a thorough subsequent washing.

Proofs printed by this process certainly possess a remarkable

richness of tone, although not superior to the best prints on albumenised paper. Neither can they be more permanent, because the same substances—viz., gold and silver, form the image in each instance. As to economy, the advantage is much in favour of the old method.

Instead of nitrate of silver, chloride of gold may be substituted in the sensitising or developing medium. In this case, the image will consist entirely of gold, and will probably possess absolute permanence; but the feeble blue tone produced even in the deepest shadows is not conducive to high pictorial effect.

Varnishes. An excellent practical account of the manufacture of varnishes, by Mr. J. W. Neil, will be found in the 49th volume of the Transactions of the Society of Arts. But the photographer is not so much concerned with knowing the particulars of this manufacture in its various branches, as with knowing the best formula for making a few of the different kinds of varnish which are used in Photography. These are as follow:—

Benzole Varnish. This may be applied to glass plates without the application of heat, and it dries very quickly, leaving a tolerably hard film, which does not become sticky at ordinary temperatures. It is made by adding finely pulverised gum dammar to pure benzole. The dammar readily dissolves, and the varnish may then be filtered through cotton wool to separate any solid particles there may be in it. The proportions are about 1 ounce of dammar to a pint of benzole. The varnish is applied to the plate exactly in the same way as collodion.

Instead of dammar, finely powdered amber may be employed, and this varnish will be found better than amber dissolved in chloroform, though probably not so good, and more costly than that made with dammar.

Spirit Varnish. This is the best varnish for photographs upon glass, but there is some little trouble and risk in applying it. It is made thus:—

Put into a glass flask

Alcohol, sp. gr. ·825 . .	20 fluid ounces.
Pulverised white lac . .	1½ ounce.

Put the flask into hot water, having previously wrapped a piece of paper loosely over the mouth of it. The ingredients are soon dissolved, and may then be filtered by passing the varnish through cotton wool.

Instead of white lac, seed-lac may be employed, but the varnish

is then of a darker colour. Methylated spirits may be used as the solvent. French polish diluted with an equal part of alcohol makes a good spirit varnish for negatives.

Before applying the varnish the plate must be dried and heated before the fire to a temperature of about 100°; not more, or there will be a risk of destroying the picture by causing it to run in smears down the glass when the superfluous varnish is poured off the plate into the bottle. On the other hand, if the plate be not heated sufficiently, the varnish will be chilled, and produce the effect of ground glass. The plate must be warmed again while the varnish is drying. When spirit varnish is properly applied, it forms an exceedingly hard and tough film, which it is difficult to scratch or injure during the process of printing, and which does not become sticky by heat.

Black Varnish. This is made by dissolving in one bottle powdered asphaltum in benzole, and in another, india-rubber in benzole; then adding the latter to the former in such proportion as may seem best, the object of the india-rubber being to prevent the black varnish from cracking.

The india-rubber should be cut into small pieces, and left two or three days to dissolve in the benzole, which it does without heat.

Varnishes may be divided into two classes—viz., fat varnishes and spirit varnishes; and the latter class may be subdivided into two, in one of which alcohol is the solvent, and in the other turpentine, and analogous substances.

The principal fat varnish used by painters is copal, and the principal spirit varnish mastic, but neither of these is suitable for photographic purposes. Varnish for maps and drawings may be made by adding turpentine to canada balsam in about equal parts, and gently heating the mixture. The paper should be sized with gelatine before applying the varnish. Another paper varnish may be made by digesting together—amber, 300 parts; camphor, 1 part; alcohol, 1500 parts. White lac dissolved in borax may also be used as a paper varnish. Another kind of paper varnish may be made from Xyloidine. Paper may be varnished by floating it upon albumen, drying it, and then coagulating the albumen by floating the back of the paper upon boiling water.

Vinegar. *See* "Acetic Acid."

'ision. (Latin, *videre*, to see.) The phenomenon of human on will be described under two heads; viz., monocular vision, binocular vision.

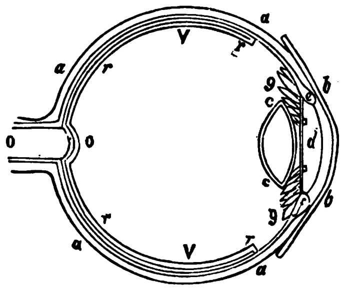
Monocular Vision.

Vision is said to be "monocular" when only one eye is employed.

The human eye may be considered as a sort of spherical camera obscura, in which the pupil (or little black dot in the centre of the eye), is the diaphragm, and the retina the focussing screen, this admirable natural camera being then placed within a socket lined with fat, in which it works by means of voluntary muscles that are attached to it, and by which its axis is directed towards any point with astonishing rapidity and precision.

The following account of the human eye is so excellent, that we extract it verbatim from a "Treatise on Optics," published by the Society for the Diffusion of Useful Knowledge:—

"The human eye, of which a vertical section is given in the following figure, is nearly of a globular form, with a slight elongation or projection in front. It consists of *four* coats or membranes, viz., the *Sclerotic*, the *Cornea*, the *Choroid*, and the *Retina;* of two fluids or humours, the *Aqueous* and the *Vitreous;* and of one lens, called the *Crystalline.* The Sclerotic coat, *a a a*, is the outer and strongest coat, to which the muscles for giving it motion are attached. It constitutes the white of the eye. It is joined to the *Cornea*, *b b*, or the clean and transparent circular membrane through which we see.



The *cornea*, which is equally thick throughout, is very tough, and consists of several layers or folds to give it strength, so as to defend the delicate parts within from external injury. On the inner surface of the sclerotic coat is a delicate membrane, called the *Choroid* coat, which is covered with a black pigment. On the inner side of this lies the *Retina*, *r r r r*, which is the innermost coat, and is a tender reticular membrane, formed from the expansion of the optic nerve, which enters the eye at O, a little more than *one-tenth* of an inch from the axis on the side towards the nose. At the end of the axis of the eye, and in the very centre of the retina, there is a small hole, with a yellow margin. It is called the *foramen centrale*, or central hole, though it is not a hole but merely a transparent spot, free of the soft pulpy matter of which the retina consists.

"A flat membrane of a circular form, *e f*, called the iris, and seen through the cornea *b b*, divides the interior globe of the eye into two

very unequal parts. It has a circular opening in its centre called the *pupil*, which *expands* when the light which enters the eye is *diminished*, and *contracts* when the light is *increased*. The space before the *iris*, called the *anterior chamber* of the eye, contains the *aqueous humour*, from its resemblance to pure water; and the space behind the iris is called the *posterior chamber*, and contains the *crystalline lens*, *c c*, and the *vitreous humour*, which fills all the rest of the eye. The *crystalline lens* is suspended in a transparent *capsule*, or *bag*, by what are called the *ciliary processes*, *g g*. This lens is more convex behind than in front, as the figure shows; and it consists of concentric coats composed of fibres. It increases in density from its circumference to its centre, for the purpose of correcting its spherical aberration. The *vitreous humour*, V V, occupying the largest portion of the eye, lies immediately behind the *crystalline lens*, and fills the whole space between it and the retina, *r r r r*.

The following are the dimensions of the eye, as given by Dr. Young and M. Petit:—

	English inches.
Length of the optical axes	0·91
Vertical chord of the cornea	0·45
Versed sine of ditto	0·11
Horizontal chord of the cornea	0·47
Opening of pupil seen through the cornea	0·27 to 0·13
Diminished by magnifying power of cornea to	0·25 to 0·12
Radius of the anterior surface of the crystalline lens	0·30
Radius of the posterior surface	0·22
Principal focal distance of the lens	1·73
Distance of the centre of the optic nerve from the central hole at the end of the axis	0·11
Distance of the iris from the cornea	0·10
Distance of the iris from the anterior surface of the crystalline	0·02
Range of the eye, or diameter of field of vision	110°

"Dr. Brewster and Dr. Gordon took the following measures of the crystalline and cornea from the eye of a woman above fifty years of age, a few hours after death:—

Diameter of the crystalline	0·378
Diameter of the cornea	0·400
Thickness of the crystalline	0·172
Thickness of the cornea	0·042

"The following are the refractive powers of the humours of the eye, according to different observers:—

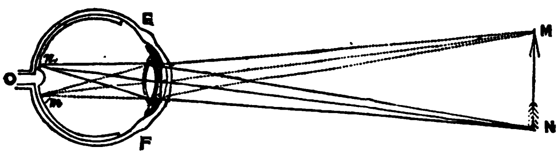
	Aqueous Humour.	Crystalline Lens. Outer Coat	Centre	Mean	Vitreous Humour
Hauksbee	1·33595	....			1·33595
Jurin	1·3333				
Rochon	1·329	....			1·332
Young	1·3333				
Brewster	1·3366	1·3767	1·3990	1·3839	1·3394

"From the last of these measures we may deduce the following indices of refraction:—

	Index of Refraction.
For rays passing from the aqueous humour into the outer coat of the crystalline lens	1·0466
For rays passing from the aqueous humour into the crystalline, taking its mean index of refraction . .	1·0353
For rays passing from the outer coat of the crystalline into the vitreous humour	0·93

"From the dimensions of the eye given above, and by means of the preceding indices of refraction, it will be easy to trace, by the method already described, the progress of rays through the humours of the eye, whether they fall upon it in a parallel or a diverging direction.

"Let MN, for example, be an object at a considerable distance



from the eye, EFO. Rays of light diverging from the points M N, will be converged by the refraction of the humours to points *m*, *n*, upon the retina, where they will form an inverted image of it, in the same manner as an image is formed in a camera obscura. That such an image is actually formed on the back of the eye may be easily proved by paring away the sclerotic coat of the eye of an ox with a sharp knife, till it is sufficiently thin to allow the image to be seen through it.

"In what manner the retina, thus impressed with a distinct image of an external object, conveys to the mind, through the medium of the optic nerve, of which it is the expanded termination, a knowledge of the existence, the position, and the magnitude of that object, is not known, and probably never will be. Certain facts, however, or laws of vision, have been deduced from observation, and merit our attentive consideration.

"1. *On the direction of visible objects.*—When the mind sees the extremity M of any object MN, by means of rays flowing from M and collected at *m*, the retina, receives these rays at different degrees of obliquity, and yet the point M is seen only in one direction, namely, in the direction of the central rays of the cone, whose apex is at *m*. This, however, does not arise from the ray being the resultant, as it were, or the mean of the directions of all the other rays; for if we close up all the pupil excepting a small opening at its

margin, the point M will be represented at *m* only by the most oblique rays of the conical pencil, and yet it will still be seen in the same direction as before. Hence we conclude, that when a ray of light falls upon any point *m* of the retina, in any direction, however oblique to its surface, the object will be seen in the direction of a line perpendicular to the retina at the point *m*. As the surface of the retina is a portion of a sphere, these perpendiculars must all pass through one point which may be called the *centre of visible direction;* because every point of an external object will be seen in the direction of a line joining that centre and the given point. The truth of this we have established by marking the perfect stability of the image of any object, when it is seen by different points of the retina when the eyeball alone is moved. Hence the centre of visible direction is a fixed point in the vitreous humour; and as it never changes its place during the rotation of the eyeball, it must be coincident with the centre round which that rotation is performed. In consequence of this coincidence, and in virtue of the law of visible direction, an arrangement of consummate skill, the great Author of nature has provided for the perfect stability of every point in the images of external objects.

"2. *Cause of erect vision.*—As the humours of the eye act exactly like a convex lens of an equivalent focal length, an *inverted* picture of external objects will, for the reasons already assigned, be formed upon the retina. Many philosophers of eminence have perplexed themselves very unnecessarily, into attempting to deduce erect vision from inverted images. The law of visible direction removes at once every difficulty; for as the lines of visible direction must necessarily cross each other at the centre of visible direction, those from the lower part of the image must go to the upper part of the object, and those from the upper part of the image go to the lower part of the object, and hence an erect object is the necessary result of an inverted image.

"3. *Distinct and indistinct vision in the same object.*—When we look intensely at any point of an object in order to examine it with care and attention, we direct to that point the axis of the eye, and consequently, the image of that point falls upon the central hole in the retina. Every other point of the same object is seen indistinctly, and the indistinctness increases with the distance of the point from that which is seen distinctly. The only perfectly distinct point of vision, therefore, is that where there is no retina; but we are not entitled to ascribe this to the absence of the nervous matter, as the gradual increase of distinctness towards the central hole does not appear to be accompanied with a gradual diminution in the ...ss of the retina.

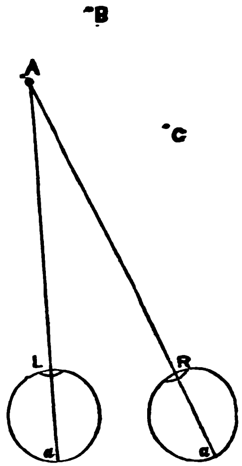
"4. *Indistinctness of vision at the base of the optic nerve.*—It was discovered by M. Mariotte, that when the image of any object fell upon the base of the optic nerve, the object disappeared. In order to prove this experimentally, fix on the side of a room, and at the height of the eye, three wafers, two feet distant. Stand opposite to the middle wafer with one eye shut, and, beginning near the wall, retire gradually from it, (looking always at the outside wafer which is on the same hand as the covered eye,) till the middle wafer disappears. This will be found to take place at about *five* times the distance at which the wafers are placed, and when it does happen, the other wafers will be plainly seen. If we use candles in place of wafers the middle one will not disappear, but it will become a cloudy mass of light. The base of the optic nerve, therefore, is not insensible to light, it is only unfit for giving distinct vision of those objects whose images fall upon it. M. Le Cat considered the size of this portion of the retina to be about one-third or one-fourth of a line; but Daniel Bernoulli found it to be about *one-seventh* part of the diameter of the eye."

The foregoing explanation is clear and accurate, with the exception of some remarks on the direction of visible objects, in paragraph 1. These it is important for us to correct. When a pencil of light from a luminous point M enters the eye and is brought to a focus at *m* upon the retina, the line of visible direction is not the axis of the cone of rays within the vitreous humour of the eye, but a line drawn perpendicular to the retina at the point *m*, and which passes through the centre of the eyeball, or, which is the same thing, through the centre of visible direction, as correctly stated in the latter part of the paragraph referred to in terms which evidently contradict the former part of the same paragraph. If the reader will draw a figure showing the course of an oblique pencil through the eye, he will perceive that the axis of the final cone of rays within the vitreous humour is a line joining the point *m*, with a point somewhere near the pupil of the eye, while the line of visible direction is a line joining *m* with a point near the centre of the eyeball. When the retina receives a blow at *m*, no matter how obliquely, the direction of the supposed force is referred by the mind to a line perpendicular to the retina at *m*.

Binocular Vision.

When both eyes are employed simultaneously vision is said to be "Binocular." The principles of it are easily explained, and will be understood by means of the following figure, and a few words of explanation.

Let L, R, be the two eyes employed simultaneously. Then only one point can be seen distinctly at any instant of time, and that is the point to which both the optic axes are directed and at which they meet, as shown by the point A in the figure. If B, C, be other points, then the mind is simply *warned* of their existence by their images upon the sides of the retinæ, and *distinct* vision of them is not obtained. But the eyeballs are capable of being turned in their sockets with extreme rapidity and precision, and the optic axes may be united at several points in succession by muscular motions which are almost instantaneous, so that it is by the comparison which the mind is able to form of the efforts made by the voluntary muscles in enlarging or contracting the angles LAR, LBR, LCR, that the most certain estimate of the comparative distance of near objects is obtained. Hence arises the important difference between monocular and binocular vision, for by means of the latter, additional certainty is given to our appreciation of distance, and hence arise all the remarkable phenomena of stereoscopic effect.



As a proof that only one object is seen distinctly at a time, it is only necessary to hold up the forefinger at a distance of a foot from the nose, and look intently at some object several yards beyond it; the finger will then appear double and transparent, distant objects being seen through it indistinctly.

No idea of the distance of an object can be obtained from the changes which take place in the focussing arrangements of a single eye to suit the different distances of objects between the limits of a few inches and infinity.

Visual Rays. *See* "Perspective."

Vitriol. "Blue vitriol" is sulphate of copper; "green vitriol" proto-sulphate of iron; "oil of vitriol" sulphuric acid; and "white vitriol" sulphate of zinc.

Volume. The space occupied by any solid body is called its "volume." Volume has *three* dimensions, viz., length, breadth, and thickness; Area *two* dimensions, viz., length and breadth; Length only ...on; and Number *no* dimensions.

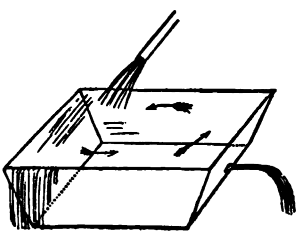
Vulcanised India-rubber, or Gutta Percha. These contain sulphur, added chiefly for the purpose of diminishing the stickiness of the surface.

Washing Prints. The following mode of washing prints appears to be as good as any that has yet been devised. The account of it was given in "Photographic Notes."

"After a print has been fixed in hypo it is of the utmost importance to remove every trace of hypo from the paper, for if any be left it will cause the print to fade. In order to remove the hypo, the print is generally washed in water changed several times, and allowed to remain in water several hours. But when a great number of prints are to be washed at the same time, a separate dish cannot be provided for each, so it is customary to put a number of prints together in the same vessel of water. When this is done they soon settle to the bottom, and lie there so closely packed that the water cannot easily get between them and soak out the hypo. It is only when the water is agitated by being changed at intervals, and for a few minutes after each change, that it gets fairly between them and acts to advantage. It is desirable, therefore, to keep the water in a state of constant agitation, so that the prints may not lie together; and this is more particularly desirable since it is found that damp favours the action of hypo in causing a print to fade. The object is therefore to remove the hypo as *quickly* and effectually as possible.

"Various plans have been proposed for accomplishing this end; and when a constant supply of water is obtainable, as it is in most large towns, it has been a common practice to leave a tap constantly running into the vessel which contains the prints, the overflow pass- into a sink beneath. But the following plan is a great improvement on this, because the prints are caused to circulate freely round the vessel, without sticking together, so long as the tap is kept running:—

"The vessel is made as in the figure, with sides slightly inclined outwards, like a washing tray. It should be square, and not too deep, or too large for the supply which is to run into it. The jet of water from the tap is directed obliquely against the further side of it near the left-hand corner; it is then reflected to the adjoining side, and thus a rotatory motion of the fluid in the direction of the arrows is established and maintained. The vessel is of course always full, and the



surplus runs over the edge, as shown in the figure. The prints immersed are in this way kept in a state of constant rotation, not *en masse*, but each print following its own particular course, without adhering to its neighbour. In order to insure the change of the water at the bottom of the vessel it may be well to make a little hole about the size of a cribbage peg, as shown in the figure."

The above method of washing paper proofs is extremely simple and effective.

Washing Machines. In order to dispense with the very tedious labour of washing photographic prints by soaking them in many successive changes of water, several ingenious contrivances have been suggested for the purpose of expediting the complete removal of the hyposulphite in which the pictures have been fixed. Mr. Grisdale's patent centrifugal machine is undoubtedly the best that has yet been suggested, and as it represents the best type of all others of the same class, we subjoin his description, copied from the specification in the Patent Office :—

" My invention relates to a peculiar construction and arrangement of centrifugal machinery or apparatus for washing photographic prints, and consists, according to one arrangement, in the employment of a peculiarly constructed revolving drum in combination with a trough, in which such drum is partially immersed. The prints to be washed are taken from the water in which they have been placed on their removal from the fixing or other bath, and are packed in one or more piles, which piles are placed round the circumference of the drum, each pile being composed of alternate prints and sheets of wire gauze or other open or reticulated fabric, so that no two prints shall be in contact with each other. These piles are held in their places on the drum by means of open frames or gratings, which bear against the opposite surfaces of each pile, and are secured to the arms of the drum by screws or otherwise, the whole or a portion of such frames or gratings forming part of the drum itself. Or, according to another arrangement, the piles above described may be laid flat upon a disc, which is made to revolve either vertically or horizontally in a trough or cistern, provision being made in the horizontal arrangement for allowing the piles to be brought in or out of contact with the water as required ; or in lieu of the photographic prints being disposed in the form of piles or packs round a drum or revolving disc, they may be laid separately or individually round the surface of a drum, a webbing of open or reticulated fabric being wound on such drum simultaneously with the placing of the prints thereon, so as to interpose a thickness of the fabric between each

succeeding layer of prints. The process of washing consists in alternately driving out the moisture from the prints by the centrifugal action of the revolving drum or disc, and saturating the prints again. During the first part of the process the prints are not immersed, but when the second part of the process, namely, the saturation, is to be effected, the trough or cistern is to be supplied with water, or the prints may be brought down into the water, and caused to revolve therein until thoroughly saturated, when the water may be run off from the trough again, or the drum or disc elevated and the moisture expelled by centrifugal force as before."

About a quarter of an hour's washing in the above described machine is considered sufficient for the object aimed at. Its action is so simple that a boy can work it with perfect ease, and we have proved from practical experience that its efficiency is all that can be desired. There only remains one subject of doubt, and that is as to how far the centrifugal force has a tendency to disintegrate the texture of tender fibred paper placed between alternate layers of wire or other gauze. We think this objection will be a serious one when the very brittle thin *Rive* papers are used for printing.

Water. HO=9. Water may be considered as the protoxide of hydrogen, being composed of one atom of oxygen and one of hydrogen; or, which is the same thing, of two volumes of hydrogen and one of oxygen.

Water in its ordinary state exists either as rain, river, or spring water.

Rain-water always contains carbonic acid, ammonia, organic matters, and sometimes nitric acid. It becomes putrid when kept. If collected in leaden vessels, oxide of lead is readily formed and a small quantity dissolved by it. Rain-water is not suitable for the nitrate bath or developer, although perhaps better than spring-water, since it does not contain salts which form precipitates with nitrate of silver.

River and spring waters contain various salts and organic impurities; the principal salts being chloride of sodium, sulphate of lime, and carbonate of lime dissolved in carbonic acid; these produce precipitates or turbidity in the water when nitrate of silver is added to it. Carbonate of lime may be thrown down by boiling the water, which expels the carbonic acid which keeps it in solution. Water is said to be "hard" when it contains salts of lime.

Water may be purified by distillation and condensation of the steam, provided it does not contain volatile oil or empyreumatic matter, which impurities are generally present in the distilled water obtained by condensing the steam from steam boilers. Perfectly

pure distilled water for delicate chemical operations is obtained by the redistillation of ordinary distilled water in silver vessels at a low temperature. It is then perfectly neutral to test paper, and a cubic inch of it at 60° weighs 252·45 grains.

Professor Tomlinson gives a very ingenious method of detecting the presence of greasy matter or empyreumatic oil in distilled water. A small piece of camphor thrown on the surface spins round if the water is free from these impurities, but if it contains them this motion is prevented.

Water is very slightly compressible, and when submitted to sudden and violent compression becomes luminous. It freezes at 32°, and boils at 212°. In freezing, or crystallising, it expands in bulk, therefore ice floats. Water, in freezing, rejects impurities, or salts held in solution, therefore melted ice is very pure water. The combustion of 2 volumes of hydrogen and 1 of oxygen produces 2 volumes of steam. At a mean atmospheric pressure, and temperature 212°, the bulk of steam is 1689 times that of water.

Wax. This substance is supposed to be produced by the bee from the honey which it collects. Its composition is stated by Lowig as $C_{34}\ H_{34}\ O_2$; but it varies, although in every case but one there are as many equivalents of carbon as of hydrogen.

Bees' wax in its ordinary state is yellow, but is bleached by being exposed in thin ribands to the joint action of air, light, and moisture. Sometimes, however, it is bleached more expeditiously by mixing with it nitrate of soda and dilute sulphuric acid, and then traces of sulphate of soda and nitric acid are generally retained. Wax melts at 150°, and is almost entirely soluble in boiling alcohol and ether; but, on cooling, the alcohol only retains a small quantity, and the ether none. When caustic potash is added to melted wax, a soapy gelatinous substance is formed which is soluble in a large quantity of water. On adding an acid, an oily liquid forms, which solidifies on cooling, and is soluble in hot alcohol; it is probably the "Ceraine" of Ettling. Succinic acid is obtained by digesting wax for some days with nitric acid.

Many vegetables secrete wax from their leaves and stems. Instances of this occur as myrtle-wax, palm-wax, Japan-wax, Ocuba-wax, sugar-cane-wax, cork-tree-wax, &c.

White wax is commonly sold in round flat cakes, and is frequently adulterated with tallow, stearine, &c.

Wax may be mixed in any proportions with oil of turpentine. Positive prints, or sheets of paper rubbed with this mixture, acquire a high polish on the evaporation of the turpentine. The ancient

fresco paintings upon the walls of houses were varnished and preserved with wax. *See* "Encaustic Painting."

Waxed Paper Process. *See* "Calotype Process."

Waxing Apparatus. In the paper negative processes the paper is generally waxed either in the first or last stage of the operation. The best mode of doing this is to procure an oblong apparatus of zinc or pewter, made exactly on the principle of a hot water plate. This is filled with boiling water, and placed over the flame of a spirit lamp to maintain the temperature. The sheet of paper or paper negative to be waxed is then laid upon the bottom of the upper part of the apparatus, and a cake of wax rubbed over it, until the paper has completely imbibed the wax. It is then removed, and a fresh sheet introduced. When a sufficient number of sheets have been treated in this way, they are held, one at a time, before the fire, and the superfluous wax which runs off is collected in a saucer. They are afterwards ironed between sheets of blotting paper, with a moderately hot iron, until no shining patches of wax appear on either side of the paper.

Weights and Measures. It is a very unfortunate circumstance that these are not uniform all over the world. In our country the standard of lineal dimensions is the length of a pendulum vibrating seconds in the latitude of Greenwich Observatory. From this all measures of capacity and weight can be calculated, from a given bulk of distilled water taken at a certain temperature. The French linear standard is one *mètre*. It is the ten-millionth part of a quarter of the earth's meridian, and measures 39·371 English inches. This is divided or multiplied by ten, and thus constitutes a most convenient method for calculating distances. The French measures of capacity and of weight are derived from the same standard. *See* Tables in Appendix.

Whey. *See* "Serum of Milk."

White Enamel. Glass rendered white and opaque by the addition of oxide of tin. When ground it forms a beautiful substance to print upon, the negative being copied by a lens, and the wet collodion process employed.

White Lead. Carbonate of lead. This substance should never be ground by hand, but by machinery, as the minute particles which escape into the air are fearfully injurious to the health. The pallid, sickly appearance of painters is mainly attributable to the

extensive use of white lead in paint. Zinc paint is not open to the same objection.

White Fire. Mix together

24 parts of saltpetre.
7 parts of sulphur.
2 parts of realgar (red sulphide of arsenic).

Wood Spirit. *See* "Pyroxilic spirit."

Wothlytype Process. *See* "Uranium printing."

Xyloidine. Same as pyroxyline *q.v.*

Yellow Calico, Paper, &c. When used for photographic purposes the tint should verge on orange rather than green. Two layers at least should always be employed, because white light passes through the innumerable interstices between the fibres of the calico. Yellow calico is generally bleached by light, and requires to be renewed from time to time.

APPENDIX.

TABLE OF ELEMENTARY BODIES, WITH THEIR EQUIVALENTS;

(*The non-metallic elements are printed in Italics.*)

Symbol.	Name of Substance.	Equivalent.	Symbol.	Name of Substance.	Equivalent.
Al.	Aluminium	13·75	Hg.	Mercury (Hydrargyrum)	100
Sb.	Antimony (Stibium) .	122	Mo.	Molybdenum . . .	48
As.	Arsenic	75	Ni.	Nickel	28
Ba.	Barium	68·5	Nb.	Niobium	?
Bi.	Bismuth	213	N	*Nitrogen*	14
B	*Boron*	11	Os.	Osmium	100
Br.	*Bromine*	80	O	*Oxygen*	8
Cd.	Cadmium	56	Pd.	Palladium	54
Ca.	Calcium	20	P	*Phosphorus*	31
C	*Carbon*	6	Pt.	Platinum	98·6
Ce.	Cerium	46	K	Potassium (Kalium) .	39
Cl.	*Chlorine*	35·5	R	Rhodium	52
Cr.	Chromium	26·3	Rb.	Rubidium	85
Co.	Cobalt	30	Ru.	Ruthenium	52
Ta.	Columbium (Tantalum)	185	Se.	*Selenium*	40
Cu.	Copper (Cuprum) . .	31·7	Si.	*Silicon*	15
Di.	Didymium	48	Ag.	Silver (Argentum) . .	108
Er.	Erbium	?	Na.	Sodium (Natrium) . .	23
F	*Fluorine*	19	Sr.	Strontium	43·8
G	Glucinum	5	S	*Sulphur*	16
Au.	Gold (Aurum) . . .	196·6	Te.	Tellurium	64
H	*Hydrogen*	1	Tb.	Terbium	?
Il.	Ilmenium	?	Th.	Thorium	60
I	*Iodine*	127	Sn.	Tin (Stannum) . . .	59
Ir.	Iridium	99	Ti.	Titanium	24
Fe.	Iron (Ferrum) . . .	28	W.	Tungsten (Wolfram) .	100
La.	Lantanium	44	U	Uranium	60
Pb.	Lead (Plumbum) . .	103·5	V	Vanadium	68
Li.	Lithium	7	Y	Yttrium	32
Mg.	Magnesium	12·16	Zn.	Zinc	32·7
Mn.	Manganese	27·5	Zr.	Zirconium	23

BAUMÉ'S HYDROMETER, OR AREOMETER.

TABLE showing the relation between Specific Gravities and Degrees of Baumé's Hydrometer, for Liquids heavier than Water.

S.G.	B.	S.G.	B.	S.G.	B.	S.G.	B.	S.G.	B.
1·000 =	0	1·125 =	16	1·286 =	32	1·501 =	48	1·801 =	64
1·007 =	1	1·134 =	17	1·298 =	33	1·526 =	49	1·823 =	65
1·014 =	2	1·143 =	18	1·309 =	34	1·532 =	50	1·847 =	66
1·022 =	3	1·152 =	19	1·321 =	35	1·549 =	51	1·872 =	67
1·029 =	4	1·161 =	20	1·334 =	36	1·566 =	52	1·897 =	68
1·036 =	5	1·171 =	21	1·346 =	37	1·583 =	53	1·921 =	69
1·044 =	6	1·180 =	22	1·359 =	38	1·601 =	54	1·946 =	70
1·052 =	7	1·190 =	23	1·372 =	39	1·618 =	55	1·974 =	71
1·060 =	8	1·199 =	24	1·384 =	40	1·637 =	56	2·002 =	72
1·067 =	9	1·210 =	25	1·398 =	41	1·656 =	57	2·031 =	73
1·075 =	10	1·221 =	26	1·412 =	42	1·676 =	58	2·059 =	74
1·083 =	11	1·231 =	27	1·426 =	43	1·695 =	59	2·087 =	75
1·091 =	12	1·242 =	28	1·440 =	44	1·714 =	60		
1·100 =	13	1·252 =	29	1·454 =	45	1·736 =	61		
1·108 =	14	1·264 =	30	1·470 =	46	1·758 =	62		
1·116 =	15	1·275 =	31	1·485 =	47	1·779 =	63		

the above scale, 0 corresponds to pure water at 58° Faht., he numbers 1, 2, 3, &c., correspond to water containing 1, tc., per cent. by weight of common salt.

TABLE

For Liquids Lighter than Water.

S. G. B.	S. G. B.	S. G. B.
1·000 = 10	·896 = 27	·811 = 44
·993 = 11	·890 = 28	·807 = 45
·987 = 12	·885 = 29	·802 = 46
·980 = 13	·880 = 30	·798 = 47
·973 = 14	·874 = 31	·794 = 48
·967 = 15	·870 = 32	·789 = 49
·960 = 16	·864 = 33	·785 = 50
·954 = 17	·859 = 34	·781 = 51
·948 = 18	·854 = 35	·777 = 52
·942 = 19	·849 = 36	·772 = 53
·936 = 20	·844 = 37	·769 = 54
·930 = 21	·840 = 38	·764 = 55
·924 = 22	·834 = 39	·760 = 56
·918 = 23	·830 = 40	·766 = 57
·913 = 24	·825 = 41	·753 = 58
·907 = 25	·820 = 42	·749 = 59
·901 = 26	·816 = 43	·745 = 60

The Areometer for liquids heavier than water is sometimes called "pèse-acide," or "pèse-syrop"; for liquids lighter than water "pèse-esprit."

ALCOHOL.

TABLE SHOWING THE PROPORTION BY WEIGHT OF ABSOLUTE ALCOHOL (S. G. ·7938) CONTAINED IN 100 PARTS OF SPIRITS OF DIFFERENT SPECIFIC GRAVITIES, AT 60° FAHRENHEIT. (*Fownes.*)

S. G.	Per Cent. of Alcohol.	S. G.	Per Cent. of Alcohol.	S. G.	Per Cent. of Alcohol.	S. G.	Per Cent. of Alcohol.
·9991	0·5	·9638	26	·9160	51	·8581	76
·9981	1·	·9623	27	·9135	52	·8557	77
·9965	2	·9609	28	·9113	53	·8533	78
·9947	3	·9593	29	·9090	54	·8508	79
·9930	4	·9578	30	·9069	55	·8483	80
·9914	5	·9560	31	·9047	56	·8459	81
·9898	6	·9544	32	·9025	57	·8434	82
·9884	7	·9528	33	·9001	58	·8408	83
·9869	8	·9511	34	·8979	59	·8382	84
·9855	9	·9490	35	·8956	60	·8357	85
·9841	10	·9470	36	·8932	61	·8331	86
·9828	11	·9452	37	·8908	62	·8305	87
·9815	12	·9434	38	·8886	63	·8279	88
·9802	13	·9416	39	·8863	64	·8254	89
·9789	14	·9396	40	·8840	65	·8228	90
·9778	15	·9376	41	·8816	66	·8199	91
·9766	16	·9356	42	·8793	67	·8172	92
·9753	17	·9335	43	·8769	68	·8145	93
·9741	18	·9314	44	·8745	69	·8118	94
·9728	19	·9292	45	·8721	70	·8089	95
·9716	20	·9270	46	·8696	71	·8061	96
·9704	21	·9249	47	·8672	72	·8031	97
·9691	22	·9228	48	·8649	73	·8001	98
·9678	23	·9206	49	·8625	74	·7969	99
·9665	24	·9184	50	·8603	75	·7938	100
·9652	25						

ACETIC ACID.

TABLE SHOWING THE SPECIFIC GRAVITY OF ACETIC ACID AT DIFFERENT DEGREES OF DILUTION. (*Thomson.*)

Atom of Acid.		Atoms of Water.		Specific Gravity at 60°.
1	+	1	=	1·06296
1	+	2	=	1·07060
1	+	3	=	1·07084
1	+	4	=	1·07132
1	+	5	=	1·06820
1	+	6	=	1·06708
1	+	7	=	1·06349
1	+	8	=	1·05974
1	+	9	=	1·05794
1	+	10	=	1·05439

BAROMETER SCALE IN MILLIMÈTRES AND INCHES.

28 inches	=	711·187 millimètres.
29 „	=	735·587 „
30 „	=	761·986 „
31 „	=	787·386 „
1 millimètre	=	0·03937 inch.
1 inch	=	25·39954 millimètres.

NITRIC ACID.

TABLE SHOWING THE QUANTITY OF NITRIC ACID IN 100 PARTS OF DILUTE ACID OF DIFFERENT SPECIFIC GRAVITIES. (*Ure.*)

Specific Gravity of Dilute Acid.	No. of Parts of Liquid Acid, S. G. 1·5 in 100.	Number of Parts of Anhydrous Acid in 100.
1·5000	100	79·7
1·4880	95	75·715
1·4730	90	71·730
1·4570	85	67·745
1·4385	80	63·760
1·4189	75	59·775
1·3978	70	55·790
1·3732	65	51·805
1·3477	60	47·820
1·3216	55	43·835
1·2947	50	39·850
1·2644	45	35·865
1·2341	40	31·880
1·2019	35	27·895
1·1709	30	23·900
1·1403	25	19·925
1·1109	20	15·940
1·0821	15	11·955
1·0540	10	7·970
1·0267	5	3·985

he intermediate parts may be found with sufficient accuracy
mple proportion.

TABLE OF THERMOMETRICAL EQUIVALENTS.

The three graduated scales of thermometers in use are Fahrenheit's, used in Great Britain and the United States of America ; the Centigrade, used in France and Belgium ; and Reaumer's scale, used chiefly in Germany. Of all three the centigrade is much the best, and it is a pity that it is not universally adopted. Its scale is deduced from the temperature of freezing and boiling distilled water at the level of sea, when the barometer registers about 60 inches. Freezing water is marked zero, or 0° ; boiling water 100°.

Faht.	Reaumer.	Centigrade.	
212°	80°	100°	Water boils.
200	74·66	93·33	
190	70·22	87·77	
180	65·77	82·22	Alcohol boils.
170	61·33	76·66	
160	56·88	71·11	
150	52·44	65·55	
140	48	60	Liquid Ammonia boils.
130	43·55	54·44	
120	39·11	48·88	
110	34·66	43·33	
100	30.22	37·77	Blood heat; Ether boils.
90	25·77	32·22	
80	21·33	26·66	
70	16·88	21·11	
60	12·44	15·55	
50	8	10	Medium temperature of the surface of the earth.
40	3·55	4·44	
32	0	0	Water freezes.
20	−5·33	−6·66	
10	−9·77	−12·22	
0	−14·22	−17·77	Brine freezes.
−10	−18·66	−23·33	Brandy freezes.
&c.	&c.	&c.	

All other intermediate degrees may be obtained by the following rules:—

To reduce Centigrade degrees to Fahrenheit. Multiply by 9, divide by 5, and add 32.

To reduce Fahrenheit degrees to Centigrade. Subtract 32, multiply by 5, and divide by 9.

To reduce Centigrade degrees to Reaumer's. Multiply by 4, and divide by 5.

To reduce Reaumer's degrees to Centigrade. Multiply by 5, and divide by 4.

To reduce Reaumer's degrees to Fahrenheit. Multiply by 9, divide by 4, and then add 32.

To reduce Fahrenheit degrees to Reaumer. Subtract 32, multiply the difference by 4, and divide the product by 9.

FREEZING MIXTURES.

Without Ice.

Muriate of Ammonia . . .	5 parts	from + 50° to + 10°
Nitrate of Potash . . .	5 „	
Water	16 „	
Nitrate of Ammonia . . .	1 part	from + 50° to + 4°
Water	1 „	
Sulphate of Soda	3 parts	from + 50° to − 30°
Diluted Nitric Acid . . .	2 „	

With Ice.

Snow	2 parts	to − 5°
Salt	1 „	
Snow	12 parts	to − 25°
Salt	5 „	
Nitrate of Ammonia . . .	5 „	
Snow	4 parts	from 32° to − 40°
Chloride of Calcium . . .	5 „	
Snow	7 parts	from 32° to − 30°
Diluted Nitric Acid . . .	4 „	
Snow	3 parts	from + 32° to − 51°
Potash	4 „	

ENGLISH MEASURES.

LINEAL MEASURE.

The imperial yard bears to the length of a pendulum vibrating seconds of mean time in vacuo, at the sea level, in the latitude of London, the ratio 36 : 39·1393.

1 inch						
12 =	1 foot					
36 =	3 =	1 yard				
72 =	6 =	2 =	1 fathom			
198 =	$16\frac{1}{2}$=	$5\frac{1}{2}$=	1 pole, perch, or rod			
7920 =	660 =	220 =	40 =	1 furlong		
63360 =	5280 =	1760 =	320 =	8 =	1 mile	

IMPERIAL MEASURE OF CAPACITY.

The imperial gallon is the volume occupied by 10 pounds avoirdupois weight of distilled water, weighed in air at 62° Faht., the barometer being at 30 inches.

						Equivalents in grains. Distilled water 62° Faht.
1 pint						8750
2 =	1 quart					17500
8 =	4 =	1 gallon				70000
16 =	8 =	2 =	1 peck			140000
64 =	32 =	8 =	4 =	1 bushel		560000
512 =	256 =	64 =	32 =	8 =	1 quarter	4480000

APOTHECARIES MEASURE OF CAPACITY.

					Grains. Distilled water at 62° Faht.
1 minim.					0·91
60 =	1 fluid drachm				54·7
480 =	8 =	1 fluid ounce			437·5
9600 =	160 =	20 =	1 pint		8750·
76800 =	1280 =	160 =	8 =	1 gallon	70000·

IMPERIAL CUBIC MEASURE.

		Equivalents in cubic inches.		Equivalents in grains. Distilled water at 62° Faht.
1 gallon	=	277·274	=	70000
1 quart	=	69·3185	=	17500
1 pint	=	34·65925	=	8750
16 ounces	=	27·72740	=	7000
1 ounce	=	1·73296	=	437·5

ENGLISH WEIGHTS.

The grain is the same in Troy, Apothecaries, and Avoirdupois weights.

AVOIRDUPOIS WEIGHT.

						Equivalent in grains.
1 dram						27·34375
16 =	1 ounce					437·5
256 =	16 =	1 pound				7000·
3584 =	224 =	14 =	1 stone			98000·
28672 =	1792 =	112 =	8 =	1 cwt.		784000·
473440 =	35840 =	2240 =	160 =	20 =	1 ton	15680000·

TROY OR JEWELLER'S WEIGHT.

1 grain.
24 = 1 pennyweight.
480 = 20 = 1 ounce.
5760 = 240 = 12 = 1 pound.

APOTHECARIES WEIGHT.

					Symbols.
1 grain					gr.
20 =	1 scruple				℈
60 =	3 =	1 drachm			ʒ
480 =	24 =	8 =	1 ounce		℥
5760 =	288 =	96 =	12 =	1 pound	℔

Observe: 437·5 grains are considered equal to 1 ounce of nitrate of silver, the only *legal* table of weights being the *Avoirdupois*. The other tables are only occasionally used for compounding medicines, &c., but probably they will soon be discontinued.

FRENCH WEIGHTS.

				Troy Weight.			
		Troy Grains.		Lbs.	Ozs.	Drms.	Grains.
Millegramme	=	·0154					
Centigramme	=	·1543					
Decigramme	=	1·543	=				1·5
GRAMME	=	15·432	=				15·4
Decagramme	=	154·323	=			2	34
Hectogramme	=	1543·234	=		3	1	43
Kilogramme	=	15432·348	=	2	8	1	12
Myriagramme	=	154323·488	=	26	9	4	3

FRENCH MEASURE OF LENGTH.

				English.				
		English Inches.		Miles.	Furlongs.	Yards.	Feet.	Inches.
Millimètre	=	·03937						
Centimètre	=	·39371						
Decimètre	=	3·93708						
MÈTRE	=	39·37079	=			1	0	3·7
Decamètre	=	393·70790	=			10	2	9·7
Hectomètre	—	3937·079	=			109	1	1
Kilomètre	=	39370·79	=		4	213	1	10
Myriamètre	=	393707·9	=	6	1	156	0,	0

FRENCH MEASURE OF CAPACITY.

				English.				
		English Cubic Inches.		Gallons.	Pints.	Fluid ozs.	Drms.	Minims.
Millitre	=	·0610	=					16·9
Centilitre	=	·6103	=				2	50
Decilitre	=	6·1027	=			3	4	13
LITRE	=	61·027	=		1	15	2	11
Decalitre	=	610·27	=	2	1	12	5	51
Hectolitre	=	6102·7	=	22	0	7	3	8
Kilolitre	=	61027·	=	220	3	13	7	30
Myrialitre	=	610270·	=	2204	4	10	3	

DAWSON'S TABLE FOR ASCERTAINING FROM THE SPECIFIC GRAVITY THE AMOUNT OF NITRATE OF SILVER CONTAINED IN ONE FLUID OUNCE OF ANY PURE SOLUTION AT 60° FAHRENHEIT.

Grs. per fl. oz.	Sp. Gr.	Grs. per fl. oz.	Sp. Gr.	Grs. per fl. oz.	Sp. Gr.	Grs. per fl. oz.	Sp. Gr.	Grs. per fl. oz.	Sp. Gr.	Grs. per fl. oz.	Sp. Gr.
10	1,021	32	1,063	54	1,105	76	1,146	98	1,187	120	1,227
11	1,023	33	1,065	55	1,106	77	1,148	99	1,189	121	1,229
12	1,025	34	1,067	56	1,108	78	1,150	100	1,191	122	1,231
13	1,027	35	1,069	57	1,110	79	1,152	101	1,193	123	1,233
14	1,029	36	1,070	58	1,112	80	1,153	102	1,194	124	1,235
15	1,031	37	1,072	59	1,114	81	1,155	103	1,196	125	1,236
16	1,032	38	1,074	60	1,116	82	1,157	104	1,198	126	1,238
17	1,034	39	1,076	61	1,118	83	1,159	105	1,200	127	1,240
18	1,036	40	1,078	62	1,120	84	1,161	106	1,202	128	1,242
19	1,338	41	1,080	63	1,122	85	1,163	107	1,204	129	1,244
20	1,040	42	1,082	64	1,123	86	1,165	108	1,205	130	1,245
21	1,042	43	1,084	65	1,125	87	1,167	109	1,207	131	1,247
22	1,044	44	1,086	66	1,127	88	1,168	110	1,209	132	1,249
23	1,046	45	1,088	67	1,129	89	1,170	111	1,211	133	1,251
24	1,048	46	1,089	68	1,131	90	1,172	112	1,213	134	1,252
25	1,050	47	1,091	69	1,133	91	1,174	113	1,215	135	1,254
26	1,051	48	1,093	70	1,135	92	1,176	114	1,216	136	1,256
27	1,053	49	1,095	71	1,137	93	1,178	115	1,218	137	1,258
28	1,055	50	1,097	72	1,138	94	1,180	116	1,220	138	1,259
29	1,057	51	1,099	73	1,140	95	1,181	117	1,222	139	1,261
30	1,059	52	1,101	74	1,142	96	1,183	118	1,224	140	1,263
31	1,061	53	1,103	75	1,144	97	1,185	119	1,226		

CORRECTION FOR TEMPERATURE.—For every 10° below 60° *deduct* one grain from the number quoted in the Table, and for every 10° above 60° *add* one grain to the number tabulated.